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**Cover :** The INSA and the USSR Academy of Sciences begin scientific cooperation. The Programme of Scientific Exchange and Scientific Cooperation between two Academies and their Protocol was signed in Moscow on 3rd June 1980.

The photograph shows : *Sitting*—DR V. RAMALINGASWAMI, *President, INSA and* ACADEMICIAN A. P. ALEKSANDROV, *President*, USSR Academy.

Drs Y. N. Bapat, Science Counsellor, Embassy of India, O. Siddiqi, Moscow, A. P. Mitra, Secretary, INSA and Professor R. P. Bambah, Vice-President, INSA are also seen standing in the picture.

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# Scientific Explanation

JAMES WOODWARD

IN many philosophical discussions of scientific explanation examples of the following sort are taken as typical or paradigmatic[1].

(*Ex.* 1) All ravens are black.
This is raven.
This is black.

(*Ex.* 2) All iron expands when heated.
This is iron which has been heated.
This expands.

(*Ex.* 3) All water boils when heated.
This is water which has been heated.
This boils.

Many people have been struck by the apparent differences between derivations like *Ex.* 1–*Ex.* 3 and the sorts of explanations one might most naturally regard as paradigms of good scientific explanation, explanations of the sort one finds in scientific treatises and textbooks. In this essay I shall attempt to isolate one such difference and to argue that it is of fundamental importance. I shall argue that there is a fundamental difference in the kind of understanding provided by derivations like *Ex.* 1–3 and the kind of understanding provided by a good scientific explanation, and that it is a defect in the standard, Hempelian version of the covering-law model that it is insensitive to this difference. I shall contend that this difference is sufficiently important to warrant one in saying that, in an important sense, derivations like *Ex.* 1–*Ex.* 3 are not scientific explanations at all, and that an acceptable scientific explanation must meet another necessary condition in addition to those standardly imposed by covering-law theorists.

**1.** I shall begin my discussion by describing in some detail several examples of explanations one might naturally describe as scientific. I shall then explore some of the similarities and differences between these explanations and explanations like (*Ex.* 1–3).

Consider, first, an explanation (*Ex.* 4) of Galileo's law in terms of Newton's laws of motion and the law of gravitation. If we assume that the earth is a sphere and that the only force on a falling body is due to the earth's gravitational attraction, we have from the above laws,

$$F = G\frac{mM}{(R+h)^2} = ma$$

where $F$ is the force on the falling body, $m$ its mass, $h$ its height above the surface of the earth, $M$ the mass of the earth, and $R$ the radius of the earth. Since $R \gg h$, we can take $(R+h) \approx R$. Then dividing through by $m$, we get

$$a = G\frac{M}{R^2}$$

When we substitute numerical values for $G$, $M$ and $R$, we obtain $g$, the actual acceleration of an object falling freely above the earth's surface.

The second explanation (*Ex.* 5) I want to consider is the standard explanation given in micro-economic theory for why a monopoly which takes over a formerly competitive industry will raise prices and restrict output.

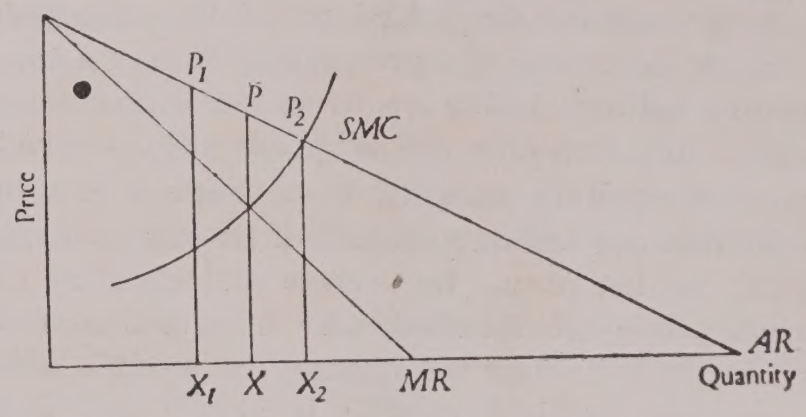


Figure 1

Consider the above diagram. When a monopoly takes over a formerly competitive industry, the demand curve of that industry becomes the demand curve, or the average revenue curve (that is the curve which gives price per unit at each level of output) for the monopolistic firm. This curve, which is labelled *AR* in the diagram above, will be downward sloping—price will be inversely related to quantity of product sold. The curve labelled *MR* in the above diagram is the marginal revenue curve (that is,

[1]The second and third examples are taken, with slight modifications, from Carnap (1967) and Bergmann (1957) respectively.

*Note*: The Indian National Science Academy gratefully acknowledges Professor John Worrall, Editor, *British Journal for the Philosophy of Science* and the author for granting permission to reprint the article.

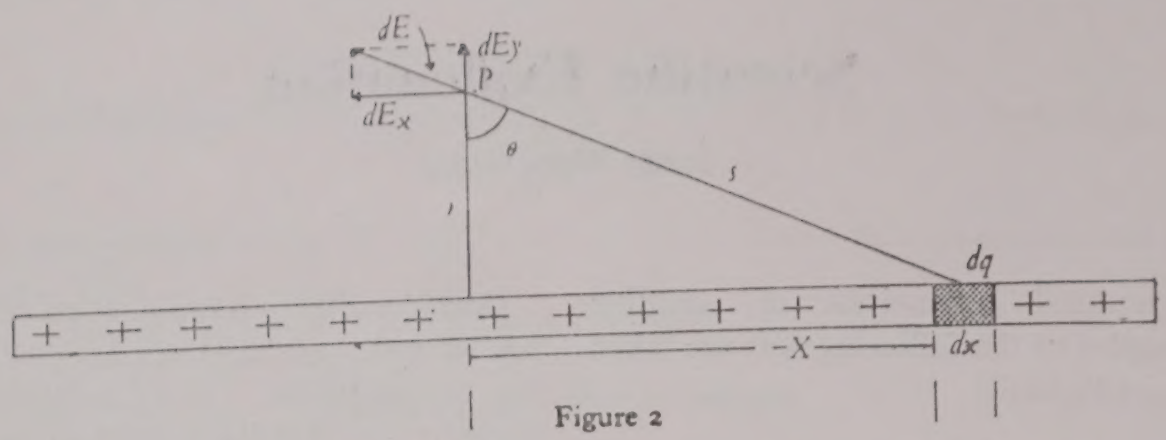


Figure 2

the curve which gives the change in total revenue occurring with each change in output) for the monopoly. Since the average revenue curve is downward sloping this curve will be more sharply downward sloping. The curve labelled *SMC* is the short-run marginal cost curve for the firm, that is the curve which indicates total change in cost for the monopoly per change in output.

Now it is easy to see that if the monopoly maximises profits it will select that price ($\bar{P}$) at which marginal revenue is equal to marginal cost. Suppose that the firm had selected price $P_1$, at which marginal revenue exceeds marginal cost. In that case, if the firm were to lower its price so that the quantity of goods demanded would rise, revenue would increase at a faster rate than costs, so that profits would rise. Thus the profit maximising firm will lower its price toward $P_1$. Suppose on the other hand that the firm had selected price $P_2$. At this price costs are increasing more quickly than revenue, and profits may be increased by increasing price until $\bar{P}$ is reached.

Now contrast the behaviour of the monopoly with the behaviour of a price taking firm in a competitive industry, before it is taken over by the monopoly. Any such firm will sell goods at $P_2$, at which price is equal to marginal cost. Such a firm by definition can sell any amount of its output at the going market price. Its average and marginal revenue curve are identical, and it cannot increase profits by restricting the quantity of goods it sells.

Because marginal revenue is always less than average revenue for the monopolistic firm, marginal cost will always exceed marginal revenue at the price $P_2$ adopted by the competitive firm. Thus the monopoly will always be, in comparison with the price taking firm, a price raiser and output restrictor—it will raise prices from $P_2$ to $\bar{P}$ and restrict quantity of goods sold from $X_2$ to $\bar{X}$.

The third explanation (*Ex.* 6) I want to consider is an explanation, in terms of Coulomb's law, of why the magnitude of the electric intensity (force per unit charge) at a perpendicular distance $r$ from a very long fine wire have a positive charge uniformly distributed along its length, is given by the expression.

$$E = \frac{I}{2\pi\epsilon_0}\frac{\lambda}{r}$$

(where $\lambda$ is the charge per unit length on the wire) and is at right angles to the wire.

We can think of the wire as divided into short segments of length $dx$, each of which may be treated as a point charge $dq$. The resultant intensity at any point will then be the vector sum of the fields set up by all these point charges. By Coulomb's law, the element $dq$ will set up a field of magnitude

$$dE = \frac{I}{4\pi\epsilon_0}\frac{dq}{s^2}$$

at a point $P$ a distance $s$ from the element. Integrating the $x$- and $y$- components of $dE$ separately, we have

$$E_x = \int dE_x = \int dE \sin\theta$$
$$E_y = \int dE_y = \int dE \cos\theta.$$

If $\lambda$ is the charge per unit length along the wire, we have $dq = \lambda dx$, and

$$dE = \frac{I}{4\pi\epsilon_0}\frac{dx}{s^2}.$$

The integration will be simplified if we integrate with respect to $d\theta$ rather than $dx$. From the above figure

$$x = r\tan\theta \quad \text{and} \quad s = r\sec\theta$$

and thus,

$$dx = r\sec^2\theta\, d\theta.$$

Making these substitutions, we obtain :

$$E_x = \frac{I}{4\pi\epsilon_0}\frac{\lambda}{r}\int \sin d\theta$$
$$E_y = \frac{I}{4\pi\epsilon_0}\frac{\lambda}{r}\int \cos\theta\, d\theta.$$

If we assume that the wire is infinitely long, the limits of integration will be from $\theta = -\pi/2$ to $\theta = \pi/2$. Integrating, we obtain

$$E_x = 0$$
$$E_y = \frac{I}{2\pi\epsilon_0}\frac{\lambda}{r}.$$

This shows that the resultant field will be at right angles to the wire and that its intensity is given by

$$E = \frac{I}{2\pi\epsilon_0}\frac{\lambda}{r} .$$

Let me begin my discussion of these three examples by noting that they do indeed conform (or very nearly conform) to the requirements laid down by the proponents of the covering-law model. That is to say, *Ex.* 4–6 are (or are very nearly) sound deductive arguments, arguments in which a law occurs as a premise which is required for the derivation of the explanandum. Moreover, *Ex.* 4–6 seem to meet the other conditions standardly imposed on scientific explanation by covering-law theorists[2].

It is true that *Ex.* 4 and *Ex.* 6 involve approximations or idealisations which are not strictly speaking true, although they are very nearly true. What can be deduced from the laws occurring in *Ex.* 4 and *Ex.* 6 and other true premises are in fact only approximations of the explananda in *Ex.* 4 and *Ex.* 6. *Ex.* 4 and *Ex.* 6 show us why their explananda are very nearly true or why the relationships they describe hold to the extent they do. Nonetheless, it would, I think, be a mistake to attach any great significance to this fact. Certainly it seems to be a mistake to suppose, as some writers apparently have[3], that satisfying or illuminating scientific explanations always involve approximate rather than strict derivations—*Ex.* 5 is an obvious counter-example and there are many others. It seems to me reasonable to take as our paradigmatic cases of scientific explanation those explanations which are sound deductive arguments and to treat explanations like *Ex.* 4 and *Ex.* 6 as acceptable because they approximate to this pattern.

It also seems clear that, as covering-law theorists have contended, a law or set of laws figures essentially in each of the above derivations (in *Ex.* 4, we have Newton's second law, and the law of gravitation; in *Ex.* 5 we have the law that all firms maximise profits; in *Ex.* 6 we have a version of Coulomb's law).

In what follows I shall assume that the covering-law model is correct as far as it goes; that is, that the covering-law model does state necessary conditions which any acceptable scientific explanation must meet. It is clear, however, that explanations (*Ex.* 1–3) as well as explanations (*Ex.* 4–6) meet all of the necessary conditions on scientific explanation so far discussed. If we wish to develop an account of scientific explanation which is sensitive to the differences between explanations (*Ex.* 1–3) and explanations (*Ex.* 4–6), we must formulate a further necessary condition on scientific explanation. I suggest the following condition, which I call the requirement of functional interdependence[4]:

> (*f*) The law occurring in the explanans of a scientific explanation of some explanandum *E* must be stated in terms of variables or parameters variations in the values of which will permit the derivation of other explananda which are appropriately different from *E*.

I shall first illustrate very briefly how this condition applies to the above explanations, and I shall then attempt to clarify it and to motivate its adoption.

Consider the generalisations which figure in explanations (*Ex.* 4–6). These generalisations contain variables or parameters (mass, distance, acceleration, price, quantity of goods, charge, electrical intensity and so forth) which are such that a whole range of different states or conditions can be characterised in terms of variations of their values. The laws in *Ex.* 4–6 formulate a systematic relation between these variables. They show us how a range of different changes in certain of these variables will be linked to changes in others of these variables. In consequence, these generalisations are such that when the variables in them assume one set of values (when we make certain assumptions about boundary and initial conditions) the explananda in the above explanations are derivable, and when the variables in them assume other sets of values, a range of other explananda are derivable. For example, the second law of motion and the law of gravitation which occur in explanation (*Ex.* 4) are such that when the variables in them assume appropriate values (values

[2] I have in mind here the additional requirements imposed by Hempel and Oppenheim in their (1948), supplemented by those imposed by Kim in his (1963), and/or requirements 7.1–7.5 imposed on singular explananda by Raimo Tuomela in chapter VII of his (1973).

[3] A position somewhat like this seems to be taken by Feyerabend in (1962).

[4] A requirement like the requirement imposed here has been imposed as a requirement on the explanation of scientific laws by several writers. For example, Ernest Nagel (1961), p. 36 holds that

> At least one of the premises in the explanation of a given law will meet the following requirements : when conjoined with suitable additional assumptions the premise should be capable of explaining other laws than the given one; on the other hand it should not in turn be possible to explain the premise with the help of the given law even when those additional assumptions are adjoined to the law.

A similar requirement is imposed by Tuomela in (1973), pp. 187ff. The requirement I impose is considerably stronger than this requirement and is imposed as a requirement on the explanation of singular explananda as well as scientific laws. My discussion below makes clear my reasons for imposing requirement (*f*) rather than Nagel's requirement.

for the mass and radius of the earth) Galileo's law is derivable. But these generalisations are also such that when the variables in them assume different values (*via* the combination of these generalisations with a different set of initial or boundary conditions) quite different explananda are derivable. For example, these generalisations are such that on the assumption that the mass and radius of the earth had different values, a quite different value for the acceleration of a falling body could be derived. These generalisations are also that we could use them to derive an expression for the rate of fall of a body falling from a distance which is no longer negligible in comparison with the earth's radius. Indeed these generalisations are such that we could use them to derive even more disparate explananda; for example, we could use them in conjunction with other information to derive Kepler's laws and a great many other derivative laws of Newtonian mechanics.

Similarly, the law which occurs in *Ex.* 5 can also be used to explain a whole range of different explananda—as *Ex.* 5 itself suggests it can be used to explain various features of the behaviour of a firm under competitive conditions and it could be used to explain other features of the behaviour of a monopolistic firm—why it will engage in product differentiation under certain conditions, for example. The law occurring in (*Ex.* 5) is such that it could be used to show that if the initial conditions facing a monopolistic firm were to change in certain ways (assume different values), the behaviour of the firm would change accordingly. (If, for example, the slope of the firm's average revenue curve were to become less steep, it would lower its prices.) And in a similar way the version of Coulomb's law occurring in (*Ex.* 6) can be used, as the parameters in this law assume different values, to explain a range of different explananda—the expressions for electrical intensity along the axis of a uniformly charged ring, or between two equally and oppositely uniformly charged plates, or inside and outside a uniformly charged hollow sphere, for example. By contrast, the generalisations occurring in (*Ex.* 1–3) do not possess these features. For example, 'Raven' and 'black' are not variables which can be used to characterise a range of different values, and 'All Ravens are black' does not formulate a systematic relationship among changes in the values of these variables. The generalisations occurring in (*Ex.* 1–3) are not such that they can be combined with a range of different assumptions about initial conditions to derive a range of different explananda in the way that the generalisation occurring in *Ex.* (4–6) can.

It is this difference between explanations (*Ex.* 1–3) and explanations (*Ex.* 4–6)—the fact that the laws occurring in the former, but not in the latter express a systematic inter-relation between variables which can assume a range of different values, and the fact that the former generalisations but not the latter can, as they assume these different values, be used to derive a range of quite different explananda—which I have attempted to capture by means of the requirement of functional interdependence.

I turn now to the task of explicating and clarifying the notion of functional interdependence. First, when are two explananda 'appropriately different'? The idea I want to capture here is the idea that the generalisations in a successful scientific explanation will permit the derivation of explananda which differ in the way in which, say, the expression for the electrical intensity at a distance from a long, uniformly charged wire differs from the expression for the electrical intensity between two equally and oppositely uniformly charged plates and not merely in the relatively trivial way in which '*a* is black' and '*b* is black' differ. I think that we can capture this idea for singular explananda if we say that two singular explananda $Ba$ and $Cb$ are appropriately different if and only if $(x)\ Bx$ does not entail $(x)\ Cx$ and $(x)\ Cx$ does not entail $(x)\ Bx$. For non-singular explananda, I shall say that $E_1$ and $E_2$ are appropriately different if and only if $E_1$ does not entail $E_2$ and vice-versa.

A more difficult problem arises with regard to specifying the meaning of the phrase 'variations in the value of a variable.' First, why do I use this cumbersome and obscure expression at all? Why don't I adopt the following simpler and more straightforward formulation of the requirement of functional interdependence?

> ($f'$) The law occurring in the explanans of a scientific explanation of some explanandum $E$ must be such that in conjunction with some appropriate set of initial or boundary conditions, it can be used to derive an explanation which is appropriately different from $E$.

Some of my reasons for preferring ($f$) will only emerge later in this essay. Nonetheless it may be helpful at this point to indicate why a simpler formation like ($f'$) won't do.

Consider to begin with the 'explanation' (*Ex.* 7)

> All ravens are black. All diamonds are green.
> *a* is a raven
> ∴ *a* is black

This explanation meets requirement ($f'$)—it is a generalisation which in conjunction with other initial conditions could be used to derive quite different explananda. Yet it clearly fails to exemplify the pattern we found in explanations (*Ex.* 4–6). If we

do not think that (*Ex.* 1) is an acceptable scientific explanation it is difficult to see why the addition of the apparently unrelated generalisation 'All diamonds are green' to the explanans of (*Ex.* 1) should turn (*Ex.* 1) into an acceptable explanation. Clearly we need to require that the generalisation occurring in a scientific explanation be such that it can be used to explain a variety of different explananda in terms of the same parameters or explanatory categories.

But it won't do either to require simply that the generalisation be such that it can be used in conjunction with the same initial condition to derive a range of different explananda. Consider (*Ex.* 8).

> All ravens are black. All ravens are cold-blooded.
>
> *a* is a raven
>
> ∴ *a* is black

Here both the blackness and cold-bloodedness of a bird is 'explained' by reference to its raven-ness. Nonetheless if we do not think that (*Ex.* 1) and (*Ex.* 7) are scientific explanations it is difficult to see why we should take (*Ex.* 8) to be a scientific explanation. It is hard to see how our understanding of why *a* is black is increased when we are told that all ravens are cold-blooded.

The pattern of explanation achieved in (*Ex.* 4–6) is in fact quite different from that achieved in arguments (*Ex.* 7) and (*Ex.* 8). The parameters appealed to in (*Ex.* 4–6) figure in the derivation of a range of different explananda, but they do so by assuming what might naturally be described as a range of different values. Informally, we can think of the parameters in (*Ex.* 4–6) as associated with scales containing different gradations, the values of these parameters being positions on these scales. The generalisations (*Ex.* 4–6) can then be thought of as showing us how certain movements along these scales (certain changes in the value of these parameters) are systematically associated with movements along other scales (changes in the values of other parameters). For example, the generalisations in *Ex.* 4 are such that they show us how increases or decreases in the mass or radius of the earth, or the distance above the earth's surface from which a stone is dropped are associated with corresponding changes in the explanandum.

It is this feature of the above explanations which I have sought to capture by use of the phrase 'value of a variable'. The sense I want to attach to this expression is roughly this: a variable may be said to have values when we may associate with the variable an ordinal and not merely nominal scale, when it is possible to talk of 'more or less' (in some non-trivial sense) in connection with the values of the variable.

Thus, to begin with, I do not understand the requirement of functional interdependence in such a way that only generalisations containing predicates associated with a ratio scale, like 'mass' or length', satisfy the requirement of functional interdependence. Consider, for example, explanations of consumer choice behaviour in terms to the generalisation that consumers will maximise expected utility, where utility va ues are measured by the method of von Neumann and Morgenstern, which establishes an interval scale. Such explanations do not merely allow us to derive a sentence about how an economic agent will behave in certain circumstances, given his utility schedule and beliefs about the probability of various outcomes. They involve a generalisation which can be used to tell us how, if an economic agent's utility schedule or probability beliefs alter in various ways, his choice behaviour will change accordingly. They are thus explanations which satisfy the requirement of functional interdependence. (They may of course have other infirmities).

A generalisation may meet the requirement of functional interdependence even if it does not contain predicates which are associated with an interval scale, so long as it contains predicates which are associated with a rough ordinal scale For example, in his essay, 'Imperfect Rationality' (Watkins [1970]), John Watkins introduces what he calls a 'step-wise likelihood scale' of subjective probability. This is a scale consisting of broad discontinuous gradations which represent a subject's classification of various events as to their subjective probability. The subject may be unable to say whether he thinks a war between the U.S. and Canada is more or less likely than a war between Britain and France, but he may think that both these possibilities fall within a broad gradation which places them considerably lower on the likelihood scale than war between Israel and Syria. And he may think that the likelihood of war between Russia and China occupies some intermediate gradation on the scale. If we assume that the value the subject assigns to various outcomes may be similarly scaled we might use the 'law' that he will maximise expected utility to explain why he chooses as he does under a variety of different kinds of situations involving uncertainty. Here only crude comparison among the subject's beliefs regarding the probabilities of various outcomes and the values he assigns to these different outcomes are possible, and we are not, as in the example above, able to measure these on an interval scale, but nonetheless at least

in some cases it seems possible, given the subject's preferences and beliefs, not only to derive how he will choose, but to say how, if his preferences and beliefs had been different, he would have chosen differently. Here too, I want to say that it is appropriate to talk of the 'values' of the subject's beliefs and preferences and of how, if those preferences and beliefs had assumed different values, he would have chosen in various different ways. Here too I want to say that this generalisation may occur in explanations satisfying the requirement of functional interdependence.

Consider another case. In his recently published study, *Religion and Regime* ([1967]) Guy Swanson undertakes to classify political regimes on a scale with five gradations, according to the extent to which governmental power in the regime is shared by the members of the political community. He also attempts to classify various religions according to the extent to which they subscribe to a belief in the immanence of God. He suggests that the items on these two scales are systematically interrelated—in particular that the extent to which governmental power in a regime is concentrated is positively correlated with the degree to which the religion to which it subscribes is committed to a belief in the immanence of God. Thus, for example, centralist regimes with a single autocrat (regimes in which power is most concentrated) are said to be typically Roman Catholic (the religion which most emphasises the immanence of God), while regimes in which a number of groups play an important role in determining governmental policy are said to be typically Calvinistic (the religion which least emphasizes the immanence of God). Regimes in various intermediate positions on the concentration-of-power scale are correlated with religions that take various intermediate positions with respect to divine immanence (Lutheranism, Anglicanism).

I do not wish to defend Swanson's 'theory' (which in fact seems to me to be rather implausible), but rather to draw the reader's attention to the fact that it seems to satisfy, in an admittedly crude way, the requirement of functional interdependence. In Swanson's account, various gradations in two magnitudes—concentration of political power and degree of belief in divine immanence—are distinguished. Swanson does not merely advance the hypothesis that some specific degree of concentration of political power is correlated with some particular religion. He also makes claims about how a range of states of concentration of political power are correlated with a range of values of a certain religious variable. His theory suggests how if the concentration of political power within a regime varies, its religious character will change and in doing so satisfies the requirement of functional interdependence with respect to certain explananda.

Similarly other predicates associated with stepwise scales which establish a crude order—indeed any vocabulary which allows us to talk about a range of phenomena in terms of gradations in a few basic parameters might conceivably occur in a scientific law which satisfies the requirement of functional interdependence.

Those cases in which, on my use of the phrase, it will be inappropriate to talk of the 'values of a variable' are cases which involve what is sometimes called a nominal scale, a scale which does not indicate an order, but only sameness or difference. Suppose, for example, that we say that $x$ is a gem if it is an emerald, ruby, or beryl. Suppose that we also say that the gem-value of $x = 1, 2$ or 3 when $x$ is respectively an emerald, a ruby, or a beryl and that the colour-value of $x = 2, 4$ or 6 when $x$ is respectively green, red or blue. Consider now the generalisation $(G_1)$ which tells us that for any gem, its colour-value will be twice its gem-value. Should we say that 1, 2 and 3 are values of the variable 'gem-value' and that $(G_1)$ satisfies the requirement of functional interdependence with regard to $(A)$ 'All emeralds are green?' Clearly we want to avoid this conclusion, for $(G_1)$ is no more than the conjunction of $(A)$ and $(B)$ 'All rubies are red' and $(C)$ 'All beryls are blue'.

The crucial difference between the artificial predicate 'gem-value' and the other predicates I have been considering seems to be something like this : in explaining what the 'gem-value' of a gem was we simply stipulated what this value was for various gems. The only requirement on this stipulation was that each of the gems we considered be assigned some (one) number, and that the same number not to be assigned to different gems. Because of this the predicate 'gem-value' does not describe an order in any non-trivial sense. If we were to discover other kinds of gems (say, sapphires or rhinestones) and ask what their gem-values were, or how (even very roughly) their gem-values compared with the gem-values of the other gems discussed above, we would have no idea how to go about answering this question, even in principle. We may contrast this with the variables 'subjective probability' or 'governmental centralisation' which Watkins and Swanson proposed to introduce. It is true that it may be difficult to say where many governments or beliefs about likelihood will fall on Swanson's or Watkins's scale, but nonetheless we have some idea about what sorts of considerations are relevant to such classifications.

Presumably there are some previously unclassified governments or beliefs that we would know, roughly at least, where to put on such scales, and, we can imagine the addition of further steps or other refinements to such scales. These features of predicates like 'subjective probability' and 'governmental centralisation' reflect the fact that, unlike a predicate like 'gem-value', they amount to something more than, so to speak, simply a list of the values they may take for various arguments. It is only when a variable possesses these features—only when in some nontrivial sense it is associated with an ordered scale—that I shall speak of 'values' of the variable, and it is only when a generalisation is stated in terms of variables which may assume different values that it will be possible for it to meet the requirement of functional interdependence.

I want now, by way of conclusion to this section, to note that the requirement of functional interdependence is at best a necessary condition and not a sufficient condition for an acceptable scientific explanation. There are many generalisations which exhibit the pattern we have called functional interdependence with respect to different potential explananda and yet which should not be regarded as explaining those explananda. We may, for example, have a theory in which the values of two variables $U_1$ and $U_2$ exhibit some regular relationship but in which $U_1$ and $U_2$ are thought of as causally unrelated, the regular relationship between them being thought of as explainable in terms of some third set of variables or conditions. In such a case we may not be able to explain variations in the value of $U_1$ in terms of variations in the value of $U_2$, even though $U_1$ and $U_2$ may exhibit the pattern of inter-relation we have called functional interdependence. For example, the Franz-Wiedemann law states that $k/T\sigma$ is a constant, where $k$ is thermal conductivity, $\sigma$ is electrical conductivity and $T$ is absolute temperature. But while this law satisfies the requirement of functional interdependence with respect to a number of different explananda, it is generally not supposed that we might use it, in conjunction with statements about the absolute temperature and thermal conductivity of a given piece of metal, to explain why the metal has the electrical conductivity it does. Rather the electrical and thermal conductivities of the metal, as well as the general relationship between them expressed in the Franz-Wiedemann law are thought of as explainable in terms of other features of the metal.

There is another very closely related feature of scientific explanation that talk of functional interdependence does not capture—it is insensitive to what is sometimes called the 'direction' of explanation. The account of scientific explanation presented here has nothing to say about why (to use Sylvain Bromberger's example) ([1966]) we are inclined to suppose that we can explain the period of a pendulum by reference to its length and yet not inclined to support that we can explain its length by reference to its period.

These examples suggest that a fully acceptable model of scientific explanation will need to embody some characteristically causal notions (*e.g.*, some notion of causal priority), or some more generalised analogue of these (*e.g.*, some notion of explanatory priority)[5]. I have not, in my remarks above, attempted to deny this but have rather contended that the covering-law model must also be supplemented in a quite different way, along the lines suggested by the requirement of functional interdependence. The features of a good scientific explanation which I have attempted to capture via the requirement of functional interdependence make a contribution to its explanatory power which is at least in part independent of the contribution made by the causal features of scientific explanation mentioned immediately above. The difference between explanations like *Ex.* 2 and *Ex.* 3 and an explanation like *Ex.* 4 does not consist in the fact that the former explanations are causal and the latter is not. A *D–N* explanation may contain a causal law and yet fall short of being a scientific explanation in the sense that *Ex.* 4–*Ex.* 6 are scientific explanations.

**2.** While I have attempted to clarify the requirement of functional interdependence I have so far said relatively little to motivate its adoption. I can best begin to do this by developing the contrast between my account of the way in which a scientific explanation provides understanding and Hempel's account in a bit more detail. In his essay 'Aspects

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[5]I leave open the question of how these causal features of scientific explanation are ultimately to be analysed or understood. It may well be that these features can be explicated in terms of some model of scientific explanation which does not presuppose them. Even Jobe's recent discussion of Bromberger's pendulum example [Jobe (1976)] seems to proceed along these lines. According to Jobe, we can deductively explain why a pendulum has a certain length without making use of the fact that it has a certain period, but any deductive explanation of its period will necessarily involve the fact that it has a certain length. This difference, according to Jobe, accounts for our willingness to explain a pendulum's period in terms of its length and our unwillingness to explain its length in terms of its period. Thus in Jobe's discussion the 'directional' character of scientific explanation is not regarded as primitive but is itself something which can be explicated in terms of a more basic notion of scientific explanation. If Jobe's discussion is correct, it provides additional support for my neglect of the 'directional' features of scientific explanation in this essay.

of Scientific Explanation' ([1965], p. 327), Hempel writes[6]

> The *D–N* argument shows that, given the particular circumstances and laws in question, the occurrence of the phenomenon was to be expected; and it is in this sense that the explanation enables us to understand why the phenomenon occurred.

If we confine ourselves to those cases of scientific explanation which involve deterministic laws we can say, I think, without serious distortion, that for Hempel a scientific explanation explains by exhibiting a nomologically sufficient condition for the explanandum, by showing us that, given certain laws and initial conditions the explanandum-phenomenon 'had' to occur, that it could be expected with certainty.

On my view, in contrast, an adequate scientific explanation provides understanding not merely by showing us this, but also by showing us how, if matters had been different in certain respects, other outcomes besides the explanandum-phenomenon would have ensued. A scientific explanation not only shows that the explanandum-phenomenon was to be expected, but also enables us to answer questions of the form 'What would have happened if ...'. A successful scientific explanation accomplishes this by exhibiting the explanandum-phenomenon as one of a range of states, any one of which might have occurred had initial conditions, boundary conditions, and so forth been different in various ways from what they actually were. We are then shown why, conditions being what they are, the explanandum-phenomenon rather than one of these alternative outcomes occurred. In effect we are not just shown that the explanandum-phenomenon had to occur, but are given some sense for the range of conditions under which it would have occurred. (It is, I take it, clear enough how, in meeting the requirement of functional interdependence, *Ex.* 4–6 exhibit these features).

But why should this additional information have explanatory significance? One way to appreciate the significance of this additional information is to note that if we simply require that an explanans provide a nomologically sufficient condition for the explanandum we do not insure that the explanans is relevant to the explanandum. When we require, in addition, that the laws in an explanans be such that they could be used to answer a set of what-if-things-had-been-different questions, we help to insure that the explanans will perspicuously identify those conditions which are relevant to the explanandum being what it is.

Let me begin with a very simple and thus possibly misleading example, which is taken from Wesley Salmon's essay 'Statistical Explanation and Statistical Relevance' [1971]. Consider the generalisation ($L_9$) 'All men who take birth control pills regularly, won't get pregnant'. This generalisation is universal in scope and supports counter-factuals. It seems to satisfy the usual syntactic conditions for law-likeness[7]. Can it then be used to explain why Mr Jones, a man who has been taking birth control pills regularly, fails to get pregnant? That is, is

(*Ex.* 9)

($L_9$) All men who take birth control pills regularly fail to get pregnant.

($C_9$) Mr Jones is a man who takes birth control pills regularly.

($E_9$) Mr Jones fails to get pregnant.

an acceptable explanation?

I think it is clear that (*Ex.* 9) is a defective explanation. While the explanans of this explanation does indeed exhibit a nomologically sufficient condition for the explanandum, it does not identify a set of factors or conditions which are relevant to the explanandum. This is of course reflected in the fact that even if Mr Jones stopped taking birth control pills, he still would not get pregnant. Given that Mr Jones is a man, whether or not he takes birth control pills has, as we say, 'nothing to do' with whether or not he gets pregnant.

Now contrast ($L_9$) with ($L_{10}$):

($L_{10}$) All women who meet condition $K$ ($K$ has to do with whether the woman is fertile, has been having intercourse regularly and so forth) and who take birth control pills regularly will not get pregnant and furthermore all women who meet condition $K$ and do not take birth control pills regularly will get pregnant.

Suppose that ($C_{10}$) Mrs Jones is a female who meets condition ($K$) and has been taking birth control pills regularly. Can ($L_{10}$) and ($C_{10}$) be used to

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[6] Cf. also 'Aspects of Scientific Explanation', pp. 367–8 where the following condition is imposed as a 'general condition of adequacy for any rationally acceptable explanation of a particular event' :

> Any rationally acceptable answer to the question 'Why did event $X$ occur?' must offer information which shows that $X$ was to be expected—if not definitely, as in the case of *D-N* explanation than at least with reasonable probability. Thus the explanatory information must provide good grounds for believing that $X$ did in fact occur; otherwise that information would give us no adequate reason for saying 'That explains it—that does show why $X$ occurred'.

[7] I put aside questions about whether the class of men, as a subclass of a biological species, involves an implicit spatio-temporal reference that disqualifies ($L_9$) from lawlikeness.

explain ($E_{10}$) why Mrs Jones doesn't get pregnant? Here of course we have considerably more inclination to say that at least a crude explanation of $E_{10}$ has been provided. The reason is obvious—whether or not Mrs Jones is taking birth control pills and meets condition $K$ does have a lot to do with whether she gets pregnant. Here the explanation given (let us call it *Ex.* 10) identifies and exhibits conditions which are not merely sufficient for, but are also relevant to $E_{10}$.

This difference is of course reflected in the fact that the explanation given for Mrs Jone's non-pregnancy shows us, while (*Ex.* 9) does not, how if conditions had been different, a different outcome would have ensued. That is to say, $L_{10}$ is such that it could be used in conjunction with a statement that Mrs Jones is not taking birth-control pills to derive the result that Mrs Jones does get pregnant. By contrast, even if we attempt to supplement $L_9$ along the lines of $L_{10}$, $L_9$ will not have this feature—it cannot be used in connection with some different set of initial conditions to derive some explanandum appropriately different from $E_9$. We may say that the explanandum given for Mrs Jones's non-pregnancy does, while explanation (*Ex.* 9) does not, identify in a crude way the range of conditions under which the associated explanandum will hold. In contrast to (*Ex.* 9), (*Ex.* 10) shows us why, a certain condition being what it is, the explanandum of (*Ex.* 10) rather than certain alternatives was realised and in so doing so shows how this condition (Mrs Jones's taking birth control pills) makes a difference for, or is relevant to, the explanandum.

I want to suggest that the features of (*Ex.* 4) which have to do with its satisfaction of the requirement of functional interdependence are important because they play an analogous role in the explanation of Galileo's law, because they help to insure that (*Ex.* 4) identifies conditions which are relevant to and not merely nomologically sufficient for the truth of Galileo's law. It is when we have an explanation which perspicuously identifies the range of conditions under which Galileo's law holds, which is such that it shows how if various conditions were different in various ways explananda other than Galileo's law would be true, that we have an explanation which shows us how these factors are relevant to the truth of Galileo's law. In a similar way it is because explanation (*Ex.* 5) does not merely provide a sufficient condition for its explanandum—that a firm facing certain conditions will exhibit a certain kind of behaviour—but also employs a generalisation which can be used to show how if the firm were faced by various different conditions (if for example, it did not face a downward-sloping demand curve) it would behave in a variety of different ways, that we can think of (*Ex.* 5) as perspicuously identifying conditions which are not merely sufficient for, but relevant to the behaviour of a monopolistic firm.

In (*Ex.* 4) and (*Ex.* 5) we have of course a considerably more detailed and general identification of the conditions under which the explananda involved obtain than we do in the case of (*Ex.* 10). (This is one of the reasons why (*Ex.* 4) and (*Ex.* 5) are considerably better explanations than (*Ex.* 10), which does not qualify as scientific at all according to our standards, since it does not involve an ordinal scale). In an explanation involving $L_{10}$ there are in effect two possible initial conditions which may obtain—Mrs Jones either may or may not take birth control pills—and two possible explananda—Mrs Jones either may or may not get pregnant. In a successful scientific explanation we have a kind of generalised analogue of this feature—the explanation identifies not two but a great range of possible explananda, and a range of possible initial conditions under which these different explananda will be realised. The explanation explains in part in virtue of showing us how it is that it was the explanandum rather than one of these many alternative possibilities that was realised and in doing so, perspicuously identifies those conditions which are relevant to the obtaining of these various explananda.

Consider another case. Suppose that $C$ is a consumer (or rational agent) who chooses alternative $A_1$ over alternative $A_2$. Suppose that we undertake to explain his choice behaviour by reference to the generalisation : ($G_2$) All consumers (or rational agents) will choose $A_1$ over $A_2$. Now contrast this explanation in terms of ($G_2$) with an explanation of *C's* choice behaviour in terms of an account like that proposed by Watkins. In comparison with the explanation in terms of ($G_2$) the explanation in terms of Watkins's account identifies in a much more perspicuous way those factors or conditions which are actually relevant to *C's* choice. On the explanation in terms of Watkins's account we are shown that $A_1$ is chosen because $A_1$ is the choice that will maximise *C's* expected utility given that $C$ has the preferences and beliefs regarding the likelihood of various outcomes that he does.

On the explanation in terms of ($G_2$) we learn only that *C's* choosing as he does has something to do with the fact that he is a consumer, or a rational agent. Our sense that the explanation in terms of Watkins's account has more perspicuously identified those factors which are relevant to *C's* choice is reflected, I have been arguing, in the fact that in this case we have an explanation which satisfies the requirement of functional interdependence, an ex-

planation which shows us how, if things had been different in various ways (if *C* had a different set of preferences or a different set of probability beliefs), *C* would have chosen in a variety of different ways.

Consider the last example. Contrast explanation (*Ex.* 1) above of why some raven, *a*, is black with what might more naturally be described as a scientific explanation of this explanandum. A scientific explanation of why some raven is black would, on my view, not simply involve some generalisation like 'All ravens are black', but would rather involve something like this : an identification of those specific biochemical reactions within ravens which produce their distinctive pigmentation, and a specification of the genetic mechanisms which are responsible for those reactions. An explanation of this kind (let us call it *Ex.* 11) would, of course, satisfy the requirements of functional interdependence. It would, for example, presumably involve an appeal to mechanisms which could be used to explain why some non-black but otherwise raven-like bird has the colour it has. It might also be an account which could be used to explain why birds of other related species have the colours they do. It would, in any event, be an account which identified the range of conditions under which the explanandum would hold, an account which makes clear how if the genetic structure of ravens, or their biochemistry were to alter in certain ways, their colour would also change. The fact that the scientific explanation of a raven's blackness possesses these features is, I contend, closely bound up with the fact that it seems to identify those factors (the genetics and biochemistry of the raven) which are relevant to the raven's blackness in a relatively perspicuous way, while explanation (*Ex.* 1) does not.

This example also suggests another important point about scientific explanation. Often our background knowledge will create definite expectations about the range of additional explananda a successful scientific explanation must be able to explain and thus definite expectations about how the requirement of functional interdependence must be met. Even if all the ravens we have observed are black, we know that there are 'anomalous' members of other species which do not have the colours characteristic of those species. We also know that the colours of many species seem to vary with their geographical location—for example, many organisms which are white in colour are found in regions in which there is a considerable amount of snow. This background knowledge creates the expectation that the account we give of the blackness of ravens will have something in common with the account we give of the colour of certain other species and because we expect that the latter account will say something about the conditions under which anomalously coloured members of those species will occur or under which the colouration of those species will vary with geographical location, we expect that the account we give of the blackness of ravens will do a similar thing. To the extent that the account we give of the blackness of ravens remains isolated and unintegrated with our background knowledge (and not how this is the case with a generalisation like 'All ravens are black') we fail to provide an adequate scientific explanation. Here, too, we see that we may have an account which exhibits a nomologically sufficient condition for the blackness of some raven, and yet which, as a consequence of its inability to explain certain other explananda, fails to provide a scientific explanation for the blackness of that raven.

There is another way of putting the contrast between my account of scientific explanation and Hempel's account. For Hempel scientific explanation is a 'local' affair. The question of whether an explanans $E_1$ explains an explanandum $E_2$ is thought of as a question which can be resolved simply by focusing our attention on $E_1$ and $E_2$. That is to say, the relation between $E_1$ and other explananda which are quite different from $E_2$ is not thought of as relevant to the question of whether $E_1$ explains $E_2$. Given this sort of orientation it is natural to think of $E_1$ as explaining $E_2$ by exhibiting (in the paradigmatic case) a nomologically sufficient condition for $E_2$. (Given this focus on the local aspects of explanation, what more could $E_1$ do?)

By contrast, on my view scientific explanation is a more global or systematic affair. Whether or not $E_1$ explains $E_2$ depends in part on the relation between $E_1$ and other sentences which are quite different from $E_2$. A scientific theory does not confer intelligibility on a set of phenomena *via* a series of local, independent exhibitions of those phenomena as necessitated. On my account the kind of understanding provided by a scientific theory rather has to do with the ability of that theory to draw together an apparently disparate set of phenomena, to account systematically for these phenomena in terms of variations in the values of the same set of parameters in some small set of laws[8].

[8]The terms 'local' and 'global' as well as the associated contrast between a conception of explanation in which scientific explanations 'confer intelligibility on individual phenomena by showing them to be...necessary' and a conception of explanation which stresses the systematic features of scientific understanding are taken from Michael Friedman's essay 'Explanation and Scientific Understanding' [1974]. However the model of scientific explanation Friedman develops differs in a number of respects from my own.

Finally, by way of conclusion to this section I want to mention two additional features of the account of scientific explanation I have sketched above. First, we may note that my account enables us to understand why the development of abstract, uniform, homogenous vocabularies generally plays such a crucial role in the construction of scientific theories. If a law or theory is to satisfy the requirement of functional interdependence in any very strong way, we must be able to characterise a large range of states in terms of variations in the values of a few basic parameters. To the extent that the vocabulary of a theory contains sharp qualitative transitions and dichotomies rather than continuous gradations, the theory will be unable to achieve the uniform treatment of a range of cases necessary to satisfy the requirement of functional interdependence. Because the vocabulary of ordinary language is generally a vocabulary which contains sharp qualitative transitions and dichotomies, it is generally not a vocabulary which can be used to formulate generalisations which satisfy the requirement of functional interdependence to any very significant degree. It is largely for this reason that scientific theories are not stated in the vocabularly of ordinary language and that the construction of a scientific theory generally requires a switch to quite different vocabulary. The characteristic flattening out or homogenising of the world which is achieved through the use of words like 'mass', 'velocity', 'energy', 'utility', 'force', and so forth is not a fortuitous feature of scientific theories but rather makes an essential contribution to their explanatory power[9].

A similar set of remarks can be made about the role played by the development of systems of measurement in the construction of scientific theories. It has often been noted that the development of precise systems of measurement in one of the most distinctive features of modern science, and it is commonly held that the scientific status of a discipline is in some way closely bound up with the availability of appropriate techniques of measurement for that discipline.

My account of scientific explanation enables us to understand why measurement should have this sort of significance—it links the explanatory power of a scientific theory to the availability of such techniques of measurement. By contrast, while there are many reasons that have nothing to do with explanation which a Hempelian might have for preferring a theory which contains quantitative laws or in which precise measurements are employed, it is not easy to see how the presence of these features might confer an explanatory advantage on a theory, given a Hempelian conception of explanation.

**3.** An account of scientific explanation in terms of functional interdependence also fits naturally with the intuitively attractive idea that a successful scientific explanation does not merely show that the explanandum phenomenon occurs regularly but also exhibits the explanandum phenomenon in a new light, allowing one to see the relevance of certain considerations which were not apparent from the original characterisation of the explanandum. Consider someone who asks for a scientific explanation of why some raven is black. Such a person (let us call him *Q*) does not, I think, merely wish for a demonstration *via* a law and some statement of initial conditions, that this raven 'had' to be black. Rather, when *Q* asks for a scientific explanation of why some raven is black, he wishes to know what it is about that raven which makes it black. *Q* is puzzled because he is unable to identify those features of a raven which are relevant to its blackness or is unaware of the laws governing those features. When *Q* is in such a situation he will not be helped, it seems to me, by being told that all ravens are black. This generalisation simply tells *Q* that all other ravens have the feature he finds puzzling about this particular raven. This information may be of interest to *Q*, but it will serve to generalise rather than dispel his original puzzlement. If *Q* does not know what it is about the explanandum phenomenon which results in its behaving as it does, this puzzlement will not be relieved when *Q* is told that the explanandum phenomenon always behaves in the way *Q* finds puzzling.

Instead, *Q* requires something quite different—an explanation that will draw his attention to further considerations the relevance of which is not apparent from *Q*'s original characterisation of the explanandum under investigation. This is what the scientific explanation of why some raven is black does. It allows us to see the raven not simply as a raven but rather as a system having a certain genetic and biochemical structure and allows us to see the relevance of the laws governing this structure to the raven's colour. We are shown that the bird possesses one kind of genetic and biochemical structure among the many different kinds of such structures different organisms may possess, and that in each case it is

[9]These remarks connect up with, and provide a further rationale for Donald Davidson's claim that we may typically expect the law 'underlying' a singular causal sentence to be stated in a technical, non-ordinary vocabulary which differs from the ordinary vocabulary in which the singular causal sentence is stated [*cf.* Donald Davidson (1967)]. This point is explored in more detail in my 'Singular Causal Explanation in History' (*forthcoming*).

the character of this structure which is relevant to an organism's colour.

I want to suggest that this is a typical feature of a successful scientific explanation—that typically such an explanation will do more than merely show us that the puzzling explanandum phenomenon occurs regularly, that it will allow us to see the explanandum phenomenon in a new light by drawing our attention to a previously unappreciated set of considerations. I shall express this by saying that a scientific explanation typically involves a 'reconstrual' of the explanandum. It should be clear that an explanation which meets the requirement of functional interdependence will, at least in many cases, possess these features. This is because an explanation which meets the requirement of functional interdependence involves seeing the explanandum phenomenon or state as one instance of a more generally characterised range of phenomena or states, the occurrence of any one of which could be explained in terms of the same generalisation, given the occurrence of the appropriate initial conditions. An explanation which fails to meet the requirement of functional interdependence—an explanation like (*Ex.* 1)—will also fail to exhibit its explanandum in a new light or to introduce a set of considerations the relevance of which was previously unappreciated. It is this failure which accounts, I believe, for the air of triviality which surrounds an explanation like (*Ex.* 1). In imposing the requirement of functional interdependence, we require that the generalisation used to explain why some raven is black go beyond this explanandum in some more ambitious sense than that evinced in (*Ex.* 1), that it do something more than simply assure us that the explanandum phenomenon occurs regularly.

Consider another example. Even in the relatively primitive account of choice-behaviour devised by Watkins, a consumer's choice of $A_1$ over $A_2$ is not explained by reference to a generalisation like 'all consumers will choose $A_1$ over $A_2$' but rather by reference to a generalisation to the effect that consumers will maximise expected utility. We come to understand why this particular consumer has chosen $A_1$ over $A_2$ not when we are told they all do, but rather when we come to see this choice as an instance of expected utility maximising behaviour. And this latter 'scientific' explanation involves the introduction of considerations which were not apparent from the initial characterisation of the explanandum as a consumer's choice of $A_1$ over $A_2$. The scientific explanation identifies, in virtue of satisfying the requirement of functional interdependence, those factors (the consumer's beliefs and preferences) which are relevant to the consumer's choice, factors which are not identified in any explanation which simply depends on the generalisation 'all consumers will choose $A_1$ over $A_2$'. An important part of the scientific explanation of the consumer's choice consists in coming to see that these factors make a difference to the consumer's choice—in coming to see that if the consumer's preferences and probability beliefs had been different in various ways he would have chosen differently. It is because an explanation in terms of Watkins's theory satisfies, at least in a crude way, the requirement of functional interdependence that it provides this sort of information and satisfies our demand for a reconstural of the explanandum.

There is a tendency among many covering-law theorists to think of the explanation of particular facts (*i.e.*, explanations in which the explananda are singular sentences) as a primary or at least typical scientific activity. But, in fact, as the examples of scientific explanation we have discussed suggest, scientific explanations typically have as their explananda generalisations rather than singular sentences. One finds, in scientific treatises and textbooks, explanations of why simple pendula have periods $T = 2\pi \sqrt{(l/g)}$, of why monopolies are output restrictors, of Boyle's and Charles's Law, of Bernouilli's equation, of the expression relating pressure and volume in gasses undergoing an adiabatic process. One does not find in addition to these explanations a distinct kind of explanation in which, *e.g.*, the period of some particular simple pendulum is explained in terms of the generalisation, 'All simple pendula have periods $= 2\pi \sqrt{(l/g)}$', or in which the output restricting behaviour of some monopolistic firm is explained by reference to the generalisation, 'All monopolistic firms are output restrictors.' To the extent that it makes sense to speak of the scientific explanation of such particular cases, the generalisations which would figure in such explanations are surely just those that would figure in the explanation of the corresponding general case. That is to say, a scientific explanation of why this $A$ and $B$ will involve just those generalisations which could be used to explain why all $A$s are $B$s. In this sense, the scientific explanation of particular facts is an activity which is derivative or parasitic on the scientific explanation of generalisations. The tendency to suppose otherwise plays, I think, no small role in making the picture of scientific explanation covering-law theorists have given us, seem plausible and attractive. Correspondingly, to the extent we see the explanation of particular facts as a derivative scientific activity we will, I think, be led to see the picture of scientific explanation

covering-law theorists have given us as misleading in certain crucial respects.

**4.** Consider one last example, which will help to draw together the disparate strands of my discussion. In a well-known passage in 'Aspects of Scientific Explanation', Hempel describes two different explanations which I have distinguished by means of brackets for later reference, of why the water level of a breaker containing a piece of floating ice will remain unchanged as the ice melts.

'A purely logical point should be noted here, however. If an explanation is of the form (*D–N*), then the laws $L_1$, $L_2$,...,.$L_r$ invoked in its explanans logically imply a law $L^*$ which by itself would suffice to explain the explanandum event by reference to the particular conditions noted in the sentences $C_1$, $C_2$,.., $C_k$. This law $L^*$ is to the effect that whenever conditions of the kind described in the sentences $C_1$, $C_2$..., the explanandum-sentences occurs. Consider an example: A chunk of ice floats in a large breaker of water at room temperature. Since the ice extends above the surface, one might expect the water level to rise as the ice melts; actually, it remains unchanged. Briefly, this can be explained as follows : [According to Archimedes' principle, a solid body floating in a liquid displaces a volume of liquid that has the same weight as the water displaced by its submerged proton. Since the melting does not change the weight, the ice turns into a mass of water of the same weight, and hence also of the same volume, as the water initially displaced by its submerged portion; consequently, the water level remains unchanged. The laws on which this account is based include Archimedes' principle, a law concerning the melting of ice at room temperature; the principle of the conservation of mass, and so on]. None of these laws mentions the particular glass of water or the particular piece of ice with which the explanation is concerned. Hence the laws imply not only that as this particular piece of ice melts in this particular glass, the water level remains unchanged, but rather the general statement $L^*$ that [under the same *kind* of circumstance, *i.e.,* when any piece of ice floats in water in any glass at room temperature, the same *kind* of phenomenon will occur, *i.e.,* the water level will remain unchanged... clearly, $L^*$ in conjunction with $C_1$, $C_2$, ... $C_k$ logically implies $E$ and could indeed be used to explain, in this context, the event described by $E$.] ([1965], p. 347)'

Whether 'minimal covering-law's like $L^*$ will always be, in any natural or interesting sense of the word, 'laws' is an interesting question but one which will not detain us here. The questions I want to consider here is rather this : assuming that $L^*$ is a law, it is law which could be used in a scientific explanation of why ($E$) the water level in some particular glass remained unchanged when the ice in it melted ?

In the above passage from Hempel, I have introduced two sets of brackets. The first set encloses a sketch of what might reasonably or naturally be regarded as a scientific explanation of $E$. The second encloses a minimal covering-law explanation to $E$. The contrast between these two explanations is, I think, quite striking and much of my discussion in this chapter can be regarded as an attempt to explicate this contrast.

Note to begin with the contrast between $L^*$ and the scientific laws—Archimedes' principle, the law of conservation of matter and so forth—which figure in the explanation enclosed in the first set of brackets. The latter but not the former are stated in that abstract vocabularly which makes possible the characterisation of a range of different cases and their systematic inter-relation. The laws which figure in the explanation enclosed in the first set of brackets are such that they can be used in conjunction with different sets of initial conditions to explain a whole range or spectrum of different explananda—thus Archimedes' principle can be used, for example, to explain why any solid body floating in a liquid displaces the volume of liquid it does. The explanation enclosed in the first set of brackets gives us some sense for the range of conditions under which the explanandum will hold. When we see the relevence of the considerations invoked in the explanans—that a solid which floats displaces a volume of liquid equal to its own weight, that no change of weight is involved when a solid melts—we see that the same reasoning could well be used to show that any solid floating in its liquid from and melting will leave the level of the liquid unchanged. Nothing in the explanation of $E$ turns essentially on the fact that a piece of ice is involved in the above example. We can also see, once we appreciate the relevance of Archimedes' principle to this case, that it does make a difference whether the solid is floating in the liquid. If, for example, the solid sinks in the liquid, then it will displace a volume of liquid equal to its own volume rather than its weight, and since a given mass of solid will generally increase in volume when it melts, the level of liquid in the container will rise as the submerged solid melts.

By contrast, the minimal covering-law explanation in terms of $L^*$ gives us no information of this kind. It can be regarded as assuring us, perhaps, that the water level in the glass 'had' to remain unchanged when the ice melted, but it does not answer the 'what if..' questions that the explanation enclosed in the first set of brackets can be used to answer. And to

say this is to say that the minimal covering-law explanation does not perspicuously exhibit the factors or conditions which are relevant to the water level in the glass remaining unchanged in the way that the explanation enclosed in the first set of brackets does. One can be aware of the information contained in the minimal covering law explanation, and yet largely fail to understand what it is about an ice cube melting in a glass that results in the water level in the glass remaining unchanged. One may be aware of $L^*$ and yet still be unclear whether the fact that the water level in the glass remained unchanged has to do with some feature peculiar to water and ice, whether it has to do with the fact that a glass rather than some other container was employed, and so forth. When we ask for a scientific explanation of $E$ we are, I think, interested in the answers to questions like these, not merely in a certification that $E$ had to be true.

We may note also the important role that a re-characterisation or reconstrual of the explanandum plays in the explanation enclosed in the first set of brackets and the complete absence of this feature in the minimal covering-law explanation. In the first explanation we begin to understand why the water-level of the glass remained unchanged as the ice-cube melted in it when we come to see the ice cube as simply one instance of a solid floating in a liquid (and hence, according to Archimedes's principle a solid which displaces a volume of liquid equal to its own weight), the melting of the cube as a process, which like any other change of state, results in no weight change, and so forth. The air of triviality which, by contrast, surrounds the minimal covering-law explanation, reflects its failure to provide any such reconstrual of $E$, any such exhibition of $E$ in a new light.

These dissimilarities between the two explanations considered above seems to me to warrant my claim that the difference between them may profitably be regarded as a difference in kind rather than merely a difference in degree. The explanation enclosed in the first set of brackets answers a kind of question which is not answered by the explanation in the second set of brackets. The first explanation does something more than merely exhibit a nomologically sufficient condition for $E$, and this something more makes a crucial difference to its character as an explanation. It is this difference I have tried to capture in characterising the first explanation as scientific and the second explanation as non-scientific.

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**References**


Bergmann, G. (1957). *Philosophy of Science.* Madison : University of Wisconsin Press.

Bromberger, S. (1966). 'Why Questions' in R. G. Colodny (*ed.*) : *University of Pittsburgh Series in the Philosophy of Science*' Vol. III : Pittsburgh, University of Pittsburgh Press, 1966, pp. 86–111.

Carnap, R. (1967). *Philosophical Foundations of Physics*, edited by Martin Gardiner, New York; Basic Books.

Davidson, D. (1967). 'Causal Relations', *Journal of Philosophy*, **64**, pp. 691–703.

Feyerabend, P. (1962). 'Explanation, Reduction, and Empiricism' in H. Feigl and G. Maxwell (*eds.*) : *Minnesota Studies in the Philosophy of Science*, vol. III: Minneapolis : University of Minnesota Press, 1962.

Friedman, Michael (1974). 'Explanation and Scientific Understanding', *Journal of Philosophy*, **71**, pp. 5–19.

Hempel, C. G. (1965). 'Aspects of Scientific Explanation' in Hempel, *Aspects of Scientific Explanation*, New York : The Free Press, 1965.

Hempel, C. G., and P. Oppenheim (1948). 'Studies in the Logic of Explanation', *Philosophy of Science*, **15**, pp. 135–75, reprinted in Hempel, *Aspects of Scientific Explanation*, New York : The Free Press, 1965.

Jobe, E. (1976). 'Discussion : A Puzzle Concerning D-N Explanation', *Philosophy of Science*, **43**, pp. 542–9.

Kim, J. (1963). 'Discussion : On the Logical Conditions of Explanation', *Philosophy of Science*, **30**, pp. 280–91.

Nagel, E. (1961). *The Structure of Science*, New York : Harcourt, Brace, and World, Inc.

Salmon, W. (1971). 'Statistical Explanation' in Salmon, *et al.*, *Statistical Explanation and Statistical Relevance* : Pittsburgh, University of Pittsburgh Press, 1971.

Swanson, G. (1967). *Religion and Regime.* Ann. Arbor : University of Michigan Press,

Tuomela, R. (1973). *Theoretical Concepts.* Wien : Springer-Verlag.

Watkins, J. (1970). 'Imperfect Rationality' in Borger and Cioffi (*eds.*) : *Explanation in the Behavioral Sciences.* Cambridge : Cambridge University Press, 1970.

# ACADEMY NEWS

## Council Meeting—August 7–8, 1980

Some important decisions taken at the 3rd Statutory Meeting of the Council for the year 1980 held on 7 and 8 August 1980 at the Library Hall, Administrative Building, Udaipur University, Udaipur, Rajasthan are reported below:

### Academy's Role in the Formation of the Science and Technology Plan

The President referred to a meeting of leading scientists of the country convened by the Department of Science & Technology at Vigyan Bhavan in New Delhi on August 2 and 3, 1980 and addressed by the Prime Minister, Shrimati Indira Gandhi. About 100 scientists were present at the meeting, called in connection with the formulation of the science and technology component of the Sixth Five Year Plan. The Prime Minister reaffirmed her faith in science and technology. It was very encouraging to learn about the provision of higher outlay in the Sixth Plan. The President referred to the statement made by Dr M. S. Swaminathan at the meeting that the Academy will have an important role in the formulation of the Science and Technology Plan.

### Standing Panel on Measures to Attract Young Talented People to Careers in Science and Technology and to sustain their Interest in Science

The Council discussed the matter of attracting, promoting and retaining talented Young Scientists. A number of suggestions were made such as modification of the career development award of the UGC, a more extensive introduction of the post-doctoral fellowship programme, an improvement of the science laboratories in schools and colleges etc. The wider question of popularisation of science was also discussed, and a number of modalities were suggested. It was decided that the following Standing Panel for this purpose be established in the Academy to make an in-depth study of the problem and make recommendations from time to time to the Department of Science & Technology and other agencies in the country.

Professor R. C. Mehrotra—*Chairman*
Professor R. P. Bambah
Professor S. C. Bhattacharyya
Professor C. N. R. Rao
Professor B. Ramachandra Rao

### COSTED International Travel Fellowship

The Indian National Committee on Science and Technology for Developing Countries at their meeting on 7 July 1980 had recommended that INSA could participate in COSTED international travel fellowship programme for young scientists below the age of 35 years by INSA contributing 25 per cent of international travel cost (about Rs. 2500/- for each) and award annually 20 such international travel grants.

### Election of Fellows

The Council unanimously recommended to the Fellows of the Academy a list of 30 scientists to be elected as Fellows.

The Council appointed a group consisting of Professor B. R. Rao, Dr A. R. Verma and Professor A. K. Sharma to streamline the format of the nomination form and provide a guideline for making recommendations.

A suggestion was made that the conveners of the Sectional Committees (who are not Council Members) may be invited to attend the Council meeting when fellowship selections are to be discussed.

### Recommendations for Election of Foreign Fellows

The Council recommended eight scientists for election as Foreign Fellows of the Academy.

### Recommendations for the Election of Council for 1981

The Council nominated the following for filling up vacancies as Officers and members of the Council* occurring in the year 1981:

| | |
|---|---|
| *President* | : Professor M. G. K. Menon (*Delhi*) |
| *Vice-Presidents* | : Professor S. C. Bhattacharyya (*Calcutta*) |
| | Dr A. S. Paintal (*Delhi*) |
| *Treasurer* | : Dr V. G. Bhide (*Delhi*) |
| *Foreign Secretary* | : Professor D. Lal (*Ahmedabad*) |
| *Secretary* | : Professor P. N. Tandon (*Delhi*) |
| *Members of Council* | : Dr S. Dhawan (*Bangalore*) |
| | Professor Ramdeo Misra (*Varanasi*) |

*Elected in October 1980

Professor H. L. Nigam (*Allahabad*)
Professor S. Raghavan (*Bombay*)
Professor M. R. Rajasekharasetty (*Mysore*)
Dr O. Siddiqi (*Bombay*)

**Consideration of the Recommendations of the Sectional Committees for the Award of Science Academy Medals for Young Scientists 1980**

The Council considered the recommendations of the Sectional Committees and recommended the award of Science Academy Medals for Young Scientists (1980) to 15 scientists as announced at the General Meeting held on 7 August 1980 (*vide Appendix II* of the Minutes of the General Meeting).

**Appointment of Sectional Committees 1981**

In every Sectional Committee, according to regulations three members are to retire every year and the Council nominates three members in their place for a further period of three years. The members retiring under each Sectional Committee on December 31, 1980, the members appointed to take their place and the composition of the Sectional Committees for the year 1981 are given in *Annexure I.*

The Council at its meeting held on 4 October 1980 appointed Professor K. S. Thind as member on Sectional Committee VI in place of Professor T. S. Sadasivan, who has regretted his inability to accept the appointment.

**Appointment of Advisory Committees**

(*a*) *Basic Sciences Committee* (1981)

The Council constituted the Basic Sciences Committee for the year 1981 as follows:

The President—*Chairman*
The Immediate Past-President
The Treasurer
The Two Secretaries

*Members nominated one each from the* 10 *Sectional Committees*

Professor J. N. Kapur
Professor K. L. Chopra
Dr Jagdish Shankar
Professor G. S. Sanyal
Dr S. K. Ghosh
Dr S. C. Agarwala
Professor U. S. Srivastava
Dr M. G. Deo
Dr P. M. Bhargava
Professor N. C. Ganguli

*Members appointed*

Professor M. S. Narasimhan
Professor H. L. Nigam

(*b*) & (*c*) *Inter-Academy Exchange Committee and Popularisation of Sciences Committee*

As authorised by the Council, the President has appointed the Inter-Academy Exchange Committee and the Popularisation of Sciences Committee 1981 (*see Annexure II*).

**Appointment of Standing Committees 1981**

The Council authorised the President to appoint Standing Committees for 1981. The Standing Committees appointed by the President for 1981 are given in *Annexure III.*

**Appointment of Advisory Boards for Awards for the year 1982**

The Council authorised the President to appoint Advisory Boards for the awards due for 1982. The President constituted the Advisory Boards for the awards for 1982 as given in *Annexure IV.*

**Consideration of the Draft Agreement of Scientific Cooperation between the Indian National Science Academy and the Hungarian Academy of Sciences**

Professor R. P. Bambah, Vice-President, INSA visited the Hungarian Academy of Sciences during June 4–7, 1980. The Hungarian Academy of Sciences had expressed their interest to establish bilateral relations with INSA. After discussions with the Vice-President of INSA, a draft agreement between the Indian National Science Academy and the Hungarian Academy of Sciences for future bilateral cooperation was signed.

The Council considered the comments received from Professor M. G. K. Menon on this point. According to Professor Menon the DST already have a Science and Technology Cooperation Programme and a Cultural Exchange Programme with Hungary, both of which provide for exchanges of scientists and professors. *Ad hoc* proposals in the areas not covered in the S & T Programme have also been made and implemented in the past. Under the circumstances the purpose and scope for a separate Agreement between INSA and the Hungarian Academy of Sciences was not clear.

The Council authorised the President INSA to discuss the matter with Professor M. G. K. Menon.

**Visit of INSA Delegation to USSR Academy of Sciences, Moscow**

An INSA Delegation consisting of Dr V. Ramalingaswami, President (leader), Professor R. P.

Bambah, Vice-President, Dr A. P. Mitra, Secretary, Dr B. S. Joshi, Professor D. Lal, Dr O. Siddiqi and Shri S. Rajan, Assistant Executive Secretary, visited the USSR Academy of Sciences from 26 May 1980 to 3 June 1980.

A programme of Scientific Exchange and Scientific Cooperation between the Indian National Science Academy and the USSR Academy of Sciences and the protocol signed by the leaders of the two sides are given in *Annexures V & VI.*

The Council considered the comments received in this connection from Professor M. G. K. Menon. A meeting is proposed to be convened between the Secretary, DST and President, INSA to discuss the matters further.

**Consideration of Time Limit for receiving the Various Awards of the Academy**

The Council recommended that the *Srinivasa Ramanujan Medal*—1968 awarded to Dr P. C. Mahalanobis may be retained in the Academy. Professor R. P. Bambah, Vice-President INSA was requested to write to Drs K. Chandrasekharan and Harish Chandra enquiring about their next visit to India so that the *Srinivasa Ramanujan Medal*—1966 and 1974 may be presented to them respectively. Their visits may be coordinated with the UGC who have arrangements for inviting eminent academicians from abroad.

**Proposal for extending Hospitality to any INSA Fellow (Indian or Foreign) normally residing in U. K. during his Visit to India**

The Council recommended that the Academy could provide hospitality for the technical visit in India of Foreign Fellows of INSA prepared in consultation with the Academy which would also make arrangement regarding local programmes of lectures in different centres in India and the courtesies due to the distinguished guests. Similar courtesy could be extended to Indian Fellows normally residing abroad.

**Publication Grants to Scientific Societies, Associations, Institutions etc.**

The Council approved the recommendations of the Grants and Symposia Committee made at its meeting held on 23 April 1980 to provide publication grants to 15 scientific societies, associations and institutions as given in *Annexure VII.*

**Financial Assistance to Workshops, Winter Schools/ Summer Schools and International Conferences**

The Council approved the recommendations of the Grants and Symposia Committee made at its meeting held on 23 April 1980 to provide financial assistance to 12 Workshops, Winter/Summer Schools, International Conferences etc. as indicated in *Annexure VIII.*

**Recommendations of the Popularisation of Sciences Committee**

Considering the Minutes of the meeting of the Advisory Committee on Popularisation of Sciences held on 23 April 1980, the recommendations were approved with amplification as detailed below :

(*a*) The Council accepted the recommendations that all local chapters be requested to take greater part in activities of popularisation of sciences and a grant of Rs. 5000/- per annum may be allowed to Bombay, Bangalore and Calcutta chapters in the first instance.

(*b*) It was mentioned that efforts should be made to invite bright students and arrange programmes of interaction with scientists.

(*c*) Lectures of interest to school children may be arranged especially on subjects fresh in the news. The programme for school children in Calcutta was proving very attractive but lack of audiovisual aids was a very serious handicap.

(*d*) A popularization award for books in English may be announced for select scientific areas and if possible, certain selected scientists be invited (to submit entries) three to five years ahead.

Dr Yash Pal mentioned the requirements of good quality software for INSAT (1981) when they will have an 1½ hour programme daily.

**INSA Local Chapter at Roorkee**

An INSA Local Chapter was formed at Roorkee with Dr Dinesh Mohan as Convener.

**Representations of INSA on the Council of the Indian Statistical Institute, Calcutta for a term of Two Years from 25 July 1980**

The following were nominated to represent INSA on the Council of the ISI, Calcutta for the two year term from 25 July 1980:

| | |
|---|---|
| Mathematician | : Professor M. S. Narasimhan |
| Statistician | : Professor S. S. Shrikhande |
| Biologist | : Professor A. K. Sharma |
| Scientist working in natural science | : Dr S. C. Bhattacharyya |

**Representation of INSA on the Advisory Board for the Award of Rabindranath Tagore Birth Centenary Plaque (1980) of the Asiatic Society, Calcutta**

Professor (Mrs) Archana Sharma was nominated to represent INSA on the Advisory Board for the

award of Rabindranath Tagore Birth Centenary Plaque (1980).

**Committee to Study the Functioning of the Secretariat and Recommend Modifications and Innovations**

A Committee under Chairmanship of Dr A. R. Verma and consisting of Professor B. R. Rao, Dr A. P. Mitra, Dr M. G. Deo and Professor H. Y. Mohan Ram was appointed to study in detail, the functioning of the INSA Secretariat and recommend any modifications and innovations.

**Miscellaneous Decisions**

Authorisation of Shri S. K. Sahni, Project Coordinator (Basic Sciences) to sign cheques drawn on behalf of the Academy during the absence from headquarters of the Executive Secretary from 22–6–80 to 20–7–1980 was reported.

Designation of Professor B. Ramachandra Rao, Treasurer, INSA to continue the functions of Dr A. P. Mitra, Secretary during his absence overseas in July 1980 was confirmed.

**Proposal for establishing an Indian Council for Biology**

A proposal for establishing an Indian Council for Biology is under consideration.

**Dr Lal reports from Woods Hole**

(1) *Third International Congress on the History of Oceanography, held at Wood Hole,* 22–26 *September,* 1980.

Dr D. Lal attended the above Congress at the Woods Hole, which celebrated the 50th anniversary of Woods Hole Oceanographic Institution (WHOI). A series of sessions dealt with the history of oceanography in other countries, history of oceanographic instrumentation, marine pollution and highlights of development of important concepts in oceanography such as the Plate Tectonic theory. Every evening, lectures were organised, which dealt with Woods Hole, Marine Numismatics, History of Scientific Illustration and the present status on the Law of the Sea. The emphasis was more on the history, i.e., dates and historical account of growth of scientific ideas in oceanography, according to the planned theme for the Congress.

(2) *SCOR Executive Committee Meeting held at Woods Hole,* 26, 27, 28 *September,* 1980

Dr D. Lal, Director, Physical Research Laboratory, Ahmedabad attended the SCOR Executive Committee meeting as an ex-officio member of EC and also as the member of National Committee of INSA, and ex-officio as the President of IAPSO. It has been decided that the level contribution of the National Committees would have to be raised by 15 per cent during 1982; and no change in 1981. The following were elected as the office bearers for the next SCOR Executive Committee :

| | |
|---|---|
| *President* | Eric Simpson |
| *Secretary* | Alan Longhurst |
| *Vice-Presidents* | 1) Henry Charnok |
| | 2) G. Siedler |
| | 3) T. Wolff |

The Secretariat has so far been housed at the Royal Society, London. It will now move to Halifax (Canada). *The address will be*: SCOR Secretariat, Executive Secretary, Elizabeth Tidmarsh, Department of Oceanography, Halifax N. S., Canada B 3H 4J1.

## International Symposium on Solar Eclipse

**(January 27–31, 1981)**

On the invitation of the Indian National Science Academy, a large number of optical astronomers, radio astronomers, ionospheric physicists and biologists from various countries visited India on the occasion of Total Solar Eclipse on 16th February 1980 to observe and take up experiments. Many successful experiments were conducted during this event both by Indian and foreign scientists.

The Academy is organising an International Symposium on Solar Eclipse for discussing the results obtained during this eclipse in India in order to compare the results with measurements made elsewhere in the world and to interpret the results in the light of present and past measurements.

The major objective of the symposium is to emphasise the interdisciplinary aspect of the measurements.

**1. Symposium Topics**

The following are the main areas in which the papers will be accepted :

(1) Optical and Radio Astronomy
(2) Ionospheric Physics and Aeronomy
(3) Atmospheric Physics and Atmospheric Electrodynamics
(4) Geomagnetism
(5) Radiation and Life Processes

**2. Venue of the Symposium**

The symposium will be held at the Academy, Premises.

# MISCELLANEOUS NEWS

**December 30–31, 1980**

Seminar on *"Exploitation of Sun, Sea and Shore-Retrospect & Prospect."*

The Seminar intends to discuss vital issues in the areas of Salt, Marine and inorganic chemicals, Desalination, Marine algae, Sea water irriculture and Solar Energy utilisation.

A felicitation ceremony is scheduled to be held at the end of the Seminar, to honour Dr D. J. Mehta, the outgoing Director, CSMCRI under whose stewardship the Institute has progressed considerably. The Seminar will be inaugurated by Professor M. G. K. Menon, Secretary, DST and the Director-General, CSIR. Shri Madhav Singh Solanki, Chief Minister of Gujarat will be the Chief Guest.

*Venue:* Central Salt & Marine Chemicals Research Institute, (CSMCRI) Bhavnagar, Gujarat.

*Correspondence to:* Shri K. S. Rao, CSMCRI.

**January 19–21, 1981**

Seminar-cum-Workshop on *"Opportunities for High Altitude Balloon Experiments in India."*

The Seminar-cum-Workshop has three primary objectives:

(i) to educate the participants about the existing facilities and capabilities, and plans for the future;

(ii) to identify the scientific and technological interests and requirements of the potential users the facility; and

(iii) to expose the participants, to the extent possible, to some of the techniques of pay load preparation, balloon launching, tracking, telecommand, telemetry and data aquisition methods and facilities. Hopefully, there would also be a demonstration balloon launch on one of the mornings, depending on weather conditions and other operations.

The deliberations of the meeting will consist of invited talks, presentation by participants, a workshop and a concluding session.

*Venue:* TIFR Balloon Facility near the ECIL Complex at Maula Ali, Hyderabad during 10 a.m.-5 p.m.

*Correspondence to:* Shri R. T. Redkar, TIFR Balloon Facility, P. B. No. 5, ECIL Post, Hyderabad-500 762.

**March 4–7, 1981**

International Symposium on *"Chemical Indices and Mechanisms of Organ Directed Toxicity."*

*Venue:* Barcelona, Spain.

*Sponsor:* IUPAC

**July 6–9, 1981**

27th International Symposium on *"Macromolecules."*

*Venue:* Strasbourg, France.

*Sponsor:* IUPAC

**July 15–21, 1981**

XII International Conference on the *"Physics of Electronic and Atomic Collisions."*

The Conference will deal with two body interactions between ions, atoms, simple molecules, electrons (negative and positive ) and photons. The collision energies of interest range from subthermal to millions of electron volts. Plasma and warm phenomena, pure atomic and molecular spectroscopy surface, and solid state physics and processes involving the structure of the nucleus lie outside the scope of the conference unless they relate directly to two-body collisions.

*Last Date for Abstracts*: March 13, 1981.

*Venue:* Gatlinburg, Tennessee, U.S.A.

*Correspondence to:* Dr Sheldon Datz, Local Chairman, Oak Ridge National Laboratory, P. O. Box X, *Oak Ridge,* TN 37830, U.S.A.

**August 9–14, 1981**

International Conference on *"Chemical Education."*

*Venue:* University of Maryland, U.S.A.

*Sponsor:* IUPAC

**August 9–15, 1981**

Symposium on *"Variations in the Global Water Budget."*

The major aim is to increase the understanding of the physical processes that control seasonal and non-seasonal variations of the global water budget. It is particularly important to establish the modes of variation of the water budget over various regions of the globe and to try to link them to changes in the large-scale circulation of the atmosphere and ocean. While a general understanding of the atmospheric

water budget exists, the oceanic water budget is still not thoroughly elucidated. There will be ten scientific programmes relating to the main theme of the Symposium.

*Venue:* School of Geography, Mansfield Road, Oxford, U. K.

*Sponsors:* (1) International Commission on Climate (ICCL) of the International Association of Meteorology and Atmospheric Physics; (2) International Association for Hydrological Sciences (IAHS); (3) Palaeoclimate Commission of the International Union for Quaternary Research (INQUA) and (4) Joint Scientific Committee (JSC) of the WMO/ICSU World Climate Research Programme.

*Correspondence to:* Professor R. E. Newell, Department of Meteorology, 54–1520, MIT, Cambridge, MAO2139, USA or Dr F. Alayne Street, School of Geography, Mansfield Road, Oxford, OX 13TB, U. K.

**August 10–18, 1981**

XX General Assembly of URSI including open Symposium on *"Millimeter and Submillimeter Waves, Remote Sensing, Mathematical Models in Radio Propagation."*

*Venue:* Washington D.C., U.S.A.

*Sponsor:* URSI of the ICSU.

**August 19, 1981**

XII International Congress of *"Nutrition."*

*Venue:* San Diego, California, U.S.A.

**August 23–29, 1981**

VII International *Biophysics Congress* and III Pan-American *Biochemistry Congress.*

The Principal aim of this event is to bring together scientists and students engaged in the various fields of biophysics, biochemistry and other areas of biological and physical sciences in recognition of the manifold interactions developed in these spheres. Both the classical and newly developing areas will be represented, thereby seeking to provide the appropriate framework for participants to obtain an overall view and a more detailed insight into their fields of interest.

The scientific programme will include plenary lectures and symposia on 20 topics, workshops and free communications. Satellite activities and an International School of Biophysics have been scheduled.

*Venue:* Mexico City, Mexico.

*Sponsors:* IUPAB, Pan-American Association of Biochemical Societies, Sociedad Mexicana de Bioquimica and Sociedad Mexicana de Ciencias Fisiologicas.

*Correspondence to:* Secretariat, VII International Biophysics Congress and III Pan-American Biochemistry Congress, Cerrada de Popocatepetl No. 51-A, Mexico 13, D.E. Mexico.

**August 25–28, 1981**

II IUPAC-IUPHAR Symposium on *"Strategy in Drug Research."*

*Venue:* Noordivijkerhout, Netherlands.

*Sponsor:* IUPAC

**August 25—September 2, 1981**

XXXI IUPAC General Assembly.

*Venue:* Leuren, Belgium.

**September 14–November 1, 1981**

*Third International Course on Applied Taxonomy of Insects and Mites of Agricultural Importance*

The Course will give participants a training in the latest trends in taxonomy with special reference to the identification of insects and mites of agricultural importance and in the procedures and practices of curation.

*Organiser:* Commonwealth Institute of Entomology, 56 Queen's Gate, London SW 75 JR, U.K. (*also venue*) with the collaboration of Commonwealth Fund for Technical Cooperation, Commonwealth Secretariat, Marlborough House, Pall Mall, London SW 1 Y 5HX, England.

*Fees*: £ 400 per participant payable in advance.

*Admission*: Only 12 students — open to suitable candidates from all countries working in the respective field of research. Application forms (ET/1 and ET/3) and other information regarding the fellowships can be obtained from the official acting as a point of contact for the CFTC aid programme in one's country/from this Institute. Completed applications must be returned to the Director at the venue, before 2nd March 1981.

**August 1–19, 1982**

XI Congress of Inter-Union for Quaternary Research.

*Venue:* Moscow, U.S.S.R.

**August 30–September 3, 1982**

IX International *"Mass Spectrometry"* Conference.

The conference will cover all aspects of Mass Spectrometry. The programme will include invited lectures, presentation of submitted papers and posters. A commercial exhibition will be organised.

*Venue:* The Historical Castle of Hofburg, Vienna, Austria.

*Sponsors:* Austrian Mass Spectrometry Group, the Austrian Society for Microchemistry and Analy-

tical Chemistry, the Austrian Chemical Society and the Institute of Analytical Chemistry of the University of Vienna.

*Correspondence to:* INTERCONVENTION, P. O. Box 105, A-1014, Vienna, Austria.
*Tel:* 576288, 576305.

The Department of Public Information of the U. N. Division for Economic and Social Information has announced a Conference on *"New and Renewable Sources of Energy"* to be held during August 1981 (dates to be finalised) in Nairobi, Kenya.

The Conference will elaborate measures for concerted actions designed to promote the development and utilization of new and renewable sources of energy with a view to meeting future overall energy requirements especially those of developing countries, particularly in the context of efforts aimed at accelerating the development of developing countries. It will provide an opportunity for countries to examine closely what can be expected from alternative sources of energy in the next decade and enable governments to make policy decisions concerning their energy requirements.

The Conference will deal with 14 energy sources. Eight panels of international specialists nominated by governments and appointed by the Secretary-General on the basis of equitable geographical, distribution are studying, respectively: solar; geothermal; wind; tidal; wave and thermal gradients of the sea; oil shale and far sands; and hydropower. Two consultant studies, one carried out by the Government Finland and the other by a distinguished Indian Specialist, will examine, respectively, heat and draught animal power.

For further information, please contact : Information Officer, U. N. Conference on New and Renewable Sources of Energy, DESI/DPI-Room 1072- C, U.N., New York, N.Y. 10017, U.S.A.

**Professor T. R. Govindachari 60th Birthday Commemoration Award in Organic Chemistry**

Professor T. R. Govindachari 60th Birthday Commemoration Award in Organic Chemistry for 1980 has been awarded to Dr S. Swaminathan, Senior Professor, Department of Organic Chemistry, University of Madras. The above award is being administered by the University of Madras from the proceeds of an endowment created during the 60th Birthday celebrations of Professor T. R. Govindachari, formerly Principal and Professor of Chemistry at the Presidency College, Madras. The value of the award is Rs. 5,000/- and the award is made once in two years to a distinguished Indian Organic Chemist working in India for published work in Organic Chemistry.

**Transfer of IUGS Secretariat**

An official notification dated November 14, 1980 issued by the Past Secretary General of the International Union of Geological Sciences (IUGS) says that the Secretariat of IUGS is transferred to Paris, France with immediate effect. All correspondence henceforth, should be directed to Dr. C. C. Weber, the Secretary General at the address:

Maison de la Geologie,
77, rue Claude Bernard Paris 75005,
France.
(Tel: (1) 707-9196, Telex: BRGM 780258 F Burgeol)

## ANNOUNCEMENTS

### INSA-INCOSTED TRAVEL FELLOWSHIP GRANTS FOR YOUNG SCIENTISTS

The Indian National Committee on Science and Technology for Developing Countries (COSTED) instituted travel fellowship grants for young scientists (below 35 years of age), intending to participate in International Conferences, short term symposia, training programmes and workshops.

Applications must reach INSA before June 30 or December 31 of each year. These applications will be considered twice a year and decisions will be communicated to the scientists. Intending applicants may write to INSA (Indian National Science Academy, Bahadur Shah Zafar Marg, New Delhi-110 002) for the standard application form.

### UTC SYSTEM

There will be *no* leap second at the end of December 1980. The date of occurrence of the leap second will be announced later by the Bureau International De L'Heure, Paris.

*Annexure—I*

# Sectional Committees-1981

**Sectional Committee—I**

[*Pure Mathematics, Theoretical and Applied Mechanics, Mathematical Astronomy, Statistics (Theory), Theoretical Fluid Mechanics, Mathematics applied to physical, biological and social theories, Operational Research, Computer Science (Theory) and Systems Analysis*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Dr M. K. Jain | 1981 |
| Professor S. Raghavan (*Secretary & Convener*) | 1981 |
| Dr S. Ramanan | 1981 |
| Dr Hansraj Gupta | 1982 |
| Dr K. R. Nair | 1982 |
| Professor R. S. Kushwaha | 1982 |
| Dr R. P. Bambah | 1983* |
| Dr J. N. Kapur | 1983* |
| Dr D. B. Lahiri@ | 1983* |

*Members retiring in* 1980

Dr S. K. Chakrabarty, Dr M. S. Raghunathan and Dr S. S. Shrikhande

**Sectional Committee—II**

[*Atomic and Molecular Physics, Solid State Physics, Low Temperature Physics, Magnetism, X-ray, Optical and Microwave Spectroscopy, X-ray Optical and Radio-Astronomy and Astrophysics, Acoustics, Crystal Physics, Ionospheric and Space Physics, Quantum Mechanics and Field Theory, Particle and High Energy Physics, Plasma Physics, Statistical and Manybody Physics, Nuclear Physics, Applied Physics excluding engineering aspects*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Dr S. Ramaseshan | 1981 |
| Professor A. K. Saha | 1981 |
| Professor B. V. Thosar | 1981 |
| Professor K. L. Chopra | 1982 |
| Professor B. R. Nag | 1982 |
| Professor P. Venkateswarlu | 1982 |
| Dr R. R. Daniel (*Secretary & Convener*) | 1983* |
| Professor B. Ramchandra Rao | 1983* |
| Dr A. R. Verma | 1983* |

*Members retiring in* 1980

Professor M. K. V. Bappu, Dr A. P. Mitra and Dr B. V. Sreekantan

**Sectional Committee—III**

[*Theoretical Chemistry, Inorganic Chemistry, Organic Chemistry, Analytical Chemistry, Physical Chemistry, Applied Chemistry, Nuclear Chemistry*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Dr A. P. B. Sinha | 1981 |
| Dr S. V. Kessar | 1981 |
| Professor C. C. Patel | 1981 |

@Dr. Lahiri has conveyed his inability. The council at its next meeting will appoint a new member in his place.

| | |
|---|---|
| Dr D. S. Bhakuni | 1982 |
| Dr M. Santappa | 1982 |
| Dr Jagdish Shankar | 1982 |
| Dr U. C. Agarwala | 1983* |
| Dr S. C. Bhattacharyya (*Secretary & Convener*) | 1983* |
| Professor R. C. Paul | 1983* |

*Members retiring in* 1980

Professor M. V. George, Professor R. C. Mehrotra and Professor H. L. Nigam

**Sectional Committee—IV**

[*Engineering, Metallurgy, Electrotechnics and Electronics, Experimental Fluid Mechanics, Technology*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Dr L. K. Doraiswamy (*Secretary & Convener*) | 1981 |
| Dr G. C. Jain | 1981 |
| Dr L. R. Vaidyanath | 1981 |
| Dr Dinesh Mohan | 1982 |
| Professor Roddam Narasimha | 1982 |
| Dr E. C. Subba Rao | 1982 |
| Dr M. A. Pai | 1983* |
| Dr G. S. Sanyal | 1983* |
| Dr C. V. Sundaram | 1983* |

*Members retiring in* 1980

Dr T. R. Anantharaman, Dr S. K. Bhattacharya and Professor S. N. Mitra

**Sectional Committee—V**

[*Meteorology, Hydrology, Oceanography (excluding Marine Biology), Geology, Geodesy, Geophysics, Geochemistry, Mineralogy, Physical Geography*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Professor V. L. S. Bhimasankaram | 1981 |
| Dr P. R Pisharoty | 1981 |
| Shri L. N. Kailasam | 1981 |
| Dr F. Ahmad | 1982 |
| Dr S. K. Ghosh | 1982 |
| Dr V. V. Sastri | 1982 |
| Dr R. C. Misra (*Secretary & Convener*) | 1983* |
| Dr S. K. Sen | 1983* |
| Dr K. S. Valdiya | 1983* |

*Members retiring in* 1980

Dr (Miss) Anna Mani, Dr K. Naha and Dr S. Z. Qasim

**Sectional Committee—VI**

[*Plant Morphology and Anatomy, Plant Taxonomy, Experimental Embryology, Plant Physiology, Mycology, Plant Ecology, Palaeobotany, Plant Cytogenetics, Plant Genetics including Genetics of Microorganisms*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Professor K. S. Bhargava | 1981 |
| Professor S. C. Maheshwari | 1981 |
| Professor V. S. Ramadas | 1981 |
| Professor S. C. Agarwala | 1982 |

| | |
|---|---|
| Dr B. C. Kundu | 1982 |
| Dr R. N. Lakhanpal | 1982 |
| Professor H. C. Gangulee | 1983* |
| Professor H. Y. Mohan Ram (*Secretary & Convener*) | 1983* |
| †Dr T S. Sadasivan | 1983* |

*Members retiring in* 1980
Professor (Mrs) Archana Sharma, Dr T. N. Khoshoo and Dr C. V. Subramanian

†Regreted inability to be on the Committee. The Council at its meeting held on 4 October 1980 appointed Professor K. S. Thind in his place.

**Sectional Committee—VII**

[*Vertebrate and Invertebrate Zoology and Palaeozoology, Human and Comparative Anatomy, Embryology, Taxonomy and Systematics, Entomology, Parasitology, Protozoology, Marine and Freshwater Zoology, Animal Ecology and Animal behaviour, Anthropology, Animal Physiology, Animal and Human Genetics, Cytogenetics*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Professor Asok Ghosh | 1981 |
| Professor M. R. Rajasekharasetty (*Secretary & Convener*) | 1981 |
| Professor J. P. Thapliyal | 1981 |
| Dr C. M. S. Dass | 1982 |
| Professor P. N. Ganapati | 1982 |
| Professor U. S. Srivastava | 1982 |
| Dr Har Swarup | 1983* |
| Dr J. S. Dutta Munshi | 1983* |
| Dr S. S. Guraya | 1983* |

*Members retiring in* 1980
Dr T. N. Ananthakrishnan, Professor E. S. Narayanan and Dr P. N. Srivastava

**Sectional Committee—VIII**

[*Medical Sciences, Microbiology, Epidemiology, Immunology, Pathology, Medical Statistics and Demography, Pharmacology, Psychiatry, Endocrinology, Biology of Reproduction, Human Physiology and Nutrition*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Dr Usha K. Luthra | 1981 |
| Dr Kamal J. Ranadive | 1981 |
| Dr K. N. Sharma | 1981 |
| Dr T. Ramakrishnan | 1982 |
| Dr J. K. Sarkar | 1082 |
| Dr P. N. Tandon (*Secretary & Convener*) | 1982 |
| Dr K. P. Bhargava | 1983* |
| Dr M. G. Deo | 1983* |
| Dr N. R. Moudgal | 1983* |

*Members retiring in* 1980
Dr N. K. Dutta, Dr Nitya Anand and Dr S. Sriramachari

**Sectional Committee—IX**

[*Biochemistry, Molecular Biophysics, Cell Biology, Molecular Genetics, Chemical Microbiology*]

| *Name of the Member* | *To Serve Until 31st December of* |
|---|---|
| Dr B. B. Biswas | 1981 |
| Dr G. C. Esh | 1981 |

| | |
|---|---|
| Professor A. N. Radhakrishnan | 1981 |
| Professor J. Ganguly (*Secretary & Convener*) | 1982 |
| Professor J. Barnabas | 1982 |
| Dr P. M. Bhargava | 1982 |
| Dr V. Jagannathan | 1983* |
| Dr P. K. Maitra | 1983* |
| Dr V. Sasisekharan | 1983* |

*Members retiring in* 1980
Dr D. P. Burma, Dr L. K. Ramachandran and Dr O. Siddiqi

**Sectional Committee—X**

[**Agriculture** : *Agronomy, Soil Sciences, Agricultural Engineering Microbiology, Agricultural Climatology, Agricultural Physics, Genetics, Cytogenetics and Plant Breeding, Horticulture, Vegetable Crops, Floriculture, Entomology including Economic Zoology, Plant Pathology, Nematology, Agricultural Chemicals, Agricultural Economics, Agricultural Extension,* **Animal Sciences** : *Animal Breeding and Genetics, Animal Physiology and Nutrition, Veterinary Bacteriology, Virology and Physiology, Dairy Chemistry and Microbiology, Dairy Technology, Fisheries Biology, Fisheries Technology, Fisheries Oceanography.* **Forestry**: *Forest Sciences—Silviculture, Forest Management, Forest Biometrics, Forest Ecology including Typology, Wood Sciences—Wood Mechanics, Wood Preservation, Wood Seasoning, Wood Engineering, Pulp and Paper Technology*]

| *Name of the Member* | *To Serve Until* 31*st December of* |
|---|---|
| Dr G. B. Deodikar | 1981 |
| Dr B. Choudhury | 1981 |
| Dr Prem Narain | 1981 |
| Dr Abrar M. Khan | 1982 |
| Dr N. G. P. Rao | 1982 |
| Dr M. S. Swaminathan (*Secretary & Convener*) | 1982 |
| Dr N. C. Ganguli | 1983* |
| Dr S. Kedharnath | 1983* |
| Dr D. P. Sadhu | 1983* |

*Members retiring in* 1980
Dr R. D. Asana, Dr S. K. Mukherjee and Dr J. S. Kanwar

*Members appointed in place of those retiring in 1980

*Annexure—II*

## Inter-Academy Exchange Committee-1981

President — *Chairman*
Vice-President (*in Delhi*)
Immediate Past-President
The Treasurer
The Foreign Secretary
The Two Secretaries
The Secretary, DST
Dr D. P. Antia
Professor R. P. Bambah
Dr Nitya Anand
Professor C. N. R. Rao
Professor O. Siddiqi

## Popularisation of Sciences Committee

President — *Chairman*
The Immediate Past-President
The Two Secretaries
Professor T. N. Ananthakrishnan
Dr P. M. Bhargava
Professor R. R. Daniel
Professor N. Balakrishnan Nair
Professor (Mrs) Archana Sharma
Professor S. K. Trehan

*Annexure—III*

# Standing Committees-1981

(a) **Building Committee**

The President — *Chairman*
Vice-President (*in Delhi*)
The Immediate Past-President
The Treasurer
The Two Secretaries
Secretary, DST, or his nominee
Dr Dinesh Mohan
Dr B. P. Pal

(b) **Finance Committee**

The President — *Chairman*
Vice-President (*in Delhi*)
The Immediate Past-President
The Treasurer
The Two Secretaries
The Two Editors of Publications
The Two Representatives of the Government of India
The Vice-Chairman of the National Commission for the Compilation of History of Sciences in India
Dr Shyama Prasad Raychaudhuri
Dr (Mrs) Usha K. Luthra
Dr Sivatosh Mookerjee

(c) **Grants & Symposia Committee**

The President — (*Chairman*)
Vice-President (*in Delhi*)
The Immediate Past-President
The Treasurer
The Foreign Secretary
The Two Secretaries
The Two Editors of Publications
Dr V. K. Gaur
Dr J. S. Kanwar
Professor K. N. Saxena
Professor M. M. Sharma

(d) **Library Committee**

The President — *Chairman*
Vice-President (*in Delhi*)
The Immediate Past-President
The Two Secretaries
The Two Editors of Publications
Professor F. C. Auluck
Dr S. Z. Qasim
Dr B. K. Anand (*Fellow incharge Library*)

(e) **Establishment Committee**

The President — *Chairman*
Vice-President (*in Delhi*)
The Immediate Past-President
The Treasurer
The Two Secretaries
The Executive Secretary
Professor B. Ramachandra Rao
Professor B. M. Johri
Professor R. C. Mehrotra

(f) **Publication Advisory Board**

The President — *Chairman*
Vice-President (*in Delhi*)
The Immediate Past-President
The Treasurer
The Two Secretaries
The Two Editors of Publications
Shri Y. R. Chadha
Professor S. K. Joshi
Professor P. T. Narasimhan
Professor P. N. Srivastava

**Editorial Boards**

(i) *Indian Journal of Pure and Applied Mathematics*

Professor S. K. Trehan (*Editor of Publications*)
Professor Alan Baker, FRS
Dr A. S. Gupta
Professor J. N. Kapur
Dr B. D. Lahiri
Professor M. S. Narasimhan
Dr R. Narasimhan
Professor S. D. Nigam
Dr H. M. Srivastava
Dr S. M. Shah

(ii) *Proceedings Part 'A'*

Professor S. K. Trehan (*Editor of Publications*)
Dr K. D. Abhyankar
Professor S. B. Bhatia
Professor Cyril Ponnamperuma
Professor R. R. Daniel
Dr P. K. Das
Professor V. K. Gaur
Professor S. V. Kessar
Professor P. T. Narasimhan
Professor H. L. Nigam
Dr Manoj K. Pal
Dr T. Pradhan
Professor C. N. R. Rao
Professor M. S. Sodha
Professor E. C. G. Sudarshan

(iii) *Proceedings Part 'B'*

PROFESSOR H. Y. MOHAN RAM (*Editor of Publications*)
PROFESSOR T. N. ANANTHAKRISHNAN
PROFESSOR JOHN HESLOP-HARRISON, FRS
PROFESSOR S. KRISHNASWAMI
DR B. R. MURTY
PROFESSOR J. J. SHAH
PROFESSOR (MRS) ARCHANA SHARMA
PROFESSOR G. P. SHARMA
PROFESSOR B. I. SUNDARARAJ
PROFESSOR P. N. TANDON
PROFESSOR J. R. TATA, FRS
PROFESSOR J. P. THAPLIYAL

*Annexure—IV*

# Advisory Boards for the Awards—1982

**1. Srinivasa Ramanujan Medal**

DR V. RAMALINGASWAMI — *Chairman*
President, INSA &
Director-General
Indian Council of Medical Research,
Ansari Nagar, New Delhi-110 016

PROFESSOR M. S. RAGHUNATHAN — *Convener, S. C. I*
Professor of Mathematics
Tata Institute of Fundamental Research,
Bombay-400 005

DR A. P. MITRA — *Convener, S.C. II*
Dy. Director
National Physical Laboratory
Hillside Road, New Delhi-110 012

PROFESSOR R. C. MEHROTRA — *Convener, S.C. III*
Department of Chemistry
Rajasthan University
Jaipur

PROFESSOR G. N. RAMACHANDRAN
Professor of Mathematical Philosophy
Indian Institute of Science,
Bangalore-560 012

DR R. RAMANNA
Scientific Adviser to the Minister of Defence,
Secretary, Department of Defence Research and Development
Director-General, Research & Development
137, South Block,
New Delhi-110 011

**2. Shanti Swarup Bhatnagar Medal**

DR V. RAMALINGASWAMI — *Chairman*
President, INSA &
Director-General
Indian Council of Medical Research,
Ansari Nagar,
New Delhi-110 016

DR T. R. ANANTHARAMAN — *Convener, S.C. IV*
Professor of Metallurgy
Insitute of Technology
Banaras Hindu University
Varanasi-221 005

S.C. refers to Sectional Committee.

Dr Brahm Prakash
6/2 Jupiter Apartments
Cuffe Parade, Colaba
Bombay-400 005

Professor A. Bhattacharyya
E/3 New Staff Quarters
Jadavpur University
Calcutta-700 032

Dr D. P. Antia,
10, Judges Court Road,
Flat No. 7, Alipore
Calcutta-700 027

3. **Silver Jubilee Commemoration Medal**

Dr V. Ramalingaswami — *Chairman*
President, INSA &
Director-General
Indian Council of Medical Research,
Ansari Nagar,
New Delhi-110 016.

Dr M. S. Swaminathan — *Convener, S.C. X*
Member
Planning Commission
Yojana Bhawan
New Delhi-110 001.

Professor A. K. Sharma
Department of Botany
Calcutta University
35 Ballygunge Circular Road
Calcutta.

Dr D. P. Sadhu
506, Paranasreepalli
Calcutta-700 060

Dr B. M. Gupta
Assistant Director & Head
Division of Virology
Central Drug Research Institute
Lucknow-226 007

4. **Professor T. R. Seshadri Seventieth Birthday Commemoration Medal**

Dr V. Ramalingaswami — *Chairman*
President, INSA & Director-General,
Indian Council of Medical Research,
Ansari Nagar, New Delhi-110 016

Professor R. C. Mehrotra — *Convener, S. C. III*
Department of Chemistry,
Rajasthan University
Jaipur.

Dr S. C. Bhattacharyya
Director,
Bose Institute
93/1, Acharya Prafulla Chandra Road,
Calcutta-700 009

Dr L. K. Doraiswamy,
Director and Head,
Division of Chemical Engineering & Process Development,
National Chemical Laboratory,
Pune-411 008

Dr K. S. G. Doss
8, Balaram Road, Adyar,
Madras-600 020

**5. Vishwakarma Medal**

Dr V. Ramalingaswami — *Chairman*
President, INSA & Director-General
Indian Council of Medical Research
Ansari Nagar, New Delhi.

Dr Sukh Dev
Director,
Malti-Chem Research Centre,
Nandesari-391 340, Baroda.

Dr T. R. Anantharaman — *Convener, S. C. IV*
Department of Metallurgy,
Banaras Hindu University,
Varanasi-221 005

Dr E. C. Subba Rao,
Professor of Metallurgical Engineering,
Indian Institute of Technology,
Kanpur-208 016.

Professor L. S. Kothari,
Department of Physics,
University of Delhi,
Delhi-110 007

# Programme of Scientific Exchange and Scientific Cooperation between the Indian National Science Academy and the USSR Academy of Sciences for 1980-85

In accordance with the Agreement on the scientific exchanges and scientific cooperation between the Department of Science and Technology, Government of India and the USSR Academy of Sciences of February 18, 1975 and with the Long-term Programme of economic, commercial, scientific and technical cooperation between India and the USSR of March 14, 1979, the Indian National Science Academy and the USSR Academy of Sciences agreed upon the subjects of scientific exchanges and cooperation for 1980 to 1985 and identified the participating institutions for each subject.

## SUBJECTS FOR SCIENTIFIC COOPERATION

1. BASIC HYDROGEOLOGY

**Participating Institutions**

*Indian side* :
1. National Geophysical Research Institute, Hyderabad.
2. India Meteorological Department.
3. Indian Institute of Technology, New Delhi.
4. University of Roorkee, Roorkee.
5. Physical Research Laboratory, Ahmedabad,.

*Soviet side* :
1. Institute of Water Problems, Moscow.

2. GEOCHEMISTRY

**Participating Institutions**

*Indian side* :
1. National Geophysical Research Institute, Hyderabad.
2. Indian Institute of Science, Bangalore.
3. Physical Research Laboratory, Ahmedabad.

*Soviet side* :
1. V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow.

3. STUDIES OF LUNAR SOIL AND OTHER EXTRATERRESTRIAL MATERIALS

**Participating Institutions**

*Indian side* :
1. Physical Research Laboratory, Ahmedabad.
2. Indian Institute of Technology, Kanpur.
3. Tata Institute of Fundamental Research, Bombay.
4. Bhabha Atomic Research Centre, Bombay.

*Soviet side* :
1. V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow.

4. EARTHQUAKE PREDICTION

**Participating Institutions**

*Indian side* :
1. India Meteorological Department.
2. Central Water Power Research Station, Poona.
3. Regional Research Laboratory, Jorhat.
4. National Geophysical Research Institute, Hyderabad.
5. Tata Institute of Fundamental Research, Bombay.

*Soviet side* :
1. Institute of Physics, Moscow.
2. Institute of Seismology and Earthquakes Engineering, Academy of Sciences, Tazik, SSR, Dushanbe.
3. Institute of Seismology, Academy of Sciences, Kirghiz, Prunze.
4. V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow.

5. PLASMA PHYSICS—ASTROPHYSICAL ASPECTS

**Participating Institutions**

*Indian side* :
1. Delhi University (Department of Physics and Astrophysics), Delhi.
2. Physical Research Laboratory, Ahmedabad.
3. Raman Research Institute, Bangalore.
4. Panjab University, Chandigarh (Department of Mathematics).
5. Indian Institute of Astrophysics, Bangalore.
6. Tata Institute of Fundamental Research, Bombay.

*Soviet side* :
1. Astronomical Council of the Academy of Sciences, USSR.
2. Institute of Cosmic Research, Moscow.

6. LOW TEMPERATURE PHYSICS

**Participating Institutions**

*Indian side* :
1. National Physical Laboratory, New Delhi.
2. University of Delhi, Delhi.
3. Indian Institute of Science, Bangalore.
4. Tata Institute of Fundamental Research, Bombay.

*Soviet side* :
1. Vavilov Institute of Physical Problems, Moscow.
2. Landau Institute of Theoretical Physics, Moscow.

7. MECHANISM OF CRYSTAL GROWTH

**Participating Institutions**

*Indian side* :
1. National Physical Laboratory, New Delhi
2. Sardar Patel University, Anand.
3. Banaras Hindu University, Varanasi.
4. Indian Institute of Science, Bangalore.

*Soviet side* :
1. Institute of Crystallography, Moscow.
2. Ioffee Physico-Technical Institute, Leningrad.

8. LIQUID CRYSTALS

**Participating Institutions**

*Indian side* :
1. Raman Institute, Bangalore.
2. University of Baroda, Baroda.
3. National Physical Laboratory, New Delhi.

*Soviet side* :
1. Institute of Crystallography, Moscow.
2. Institute of Chemical Physics, Moscow.
3. Institute of Macromolecules, Leningrad.

9. RADIO ASTRONOMY (VERY LONG BASELINE INTERFEROMETRY)

**Participating Institutions**

*Indian side* :
1. Tata Institute of Fundamental Research, Radio Astronomy Centre, Ootacamund.
2. Raman Research Institute, Bangalore.
3. Physical Research Laboratory, Ahmedabad.

*Soviet side* :
1. Byurakan Astrophysical Observatory, Armenian Academy of Sciences.
2. Physics Institute (P. N. Levedev), Moscow.

10. NEUTRINO ASTRONOMY

**Participating Institutions**

*Indian side* :
1. Tata Institute of Fundamental Research, Bombay.

*Soviet side* :
1. Institute of Nuclear Research, Moscow.

11. STATISTICS AND PROBABILITY THEORY

**Participating Institutions**

*Indian side* :
1. Indian Statistical Institute, Calcutta and New Delhi.
2. University of Poona, Poona.

*Soviet side* :
1. Steklov Institute of Mathematics, Moscow and Leningrad.

12. MATHEMATICS (INCLUDING PURE AND APPLIED MATHEMATICS)

**Participating Institutions**

*Indian side* :
1. Tata Institute of Fundamental Research, Bombay.
2. Ramanujan Institute of Mathematics, Madras University, Madras.
3. Panjab University, Chandigarh.
4. Indian Institute of Technology, New Delhi.

*Soviet side* :
1. Steklov Mathematical Institute, Moscow and Leningrad.
2. Institute of Mathematics, Novosibirsk.
3. Computer Centre, Novosibirsk.

13. CHEMISTRY OF NATURAL PRODUCTS

**Participating institutions**

*Indian side* :
1. Central Drug Research Institute, Lucknow.
2. Regional Research Laboratory, Jammu.
3. Indian Institute of Experimental Medicine, Calcutta.
4. Banaras Hindu University, Varanasi.
5. National Botanical Research Institute, Lucknow.
6. Bose Institute, Calcutta.
7. Delhi University.

*Soviet side* :
1. Shemyakin Institute of Bio-organic Chemistry, Moscow.
2. Institute of Bio-organic Chemistry, Tashkent.
3. Institute of Albumin, Pushchino.
4. Institute of Chemistry of Plant Materials, Tashkent.

14. MODERN BIOLOGY (INCLUDING CELL AND MOLECULAR BIOLOGY, DEVELOPMENTAL BIOLOGY, NEUROBIOLOGY AND THEORETICAL BIOLOGY)

(*a*) PHYSICO-CHEMICAL FOUNDATIONS OF BIOLOGY; STUDIES OF PEPTIDES AND MACRO-MOLECULES OF BIOLOGICAL INTEREST

**Participating Institutions**

*Indian side* :
1. Indian Institute of Science, Bangalore.
2. Indian Institute of Experimental Medicine, Calcutta.
3. Tata Institute of Fundamental Research, Bombay.
4. Centre for Cellular and Molecular Biology, Regional Research Laboratory, Hyderabad.

*Soviet side* :
1. Shemayakin Institute of Organic Chemistry, Moscow.
2. Institute of Bio-organic Chemistry, Tashkent.
3. Institute of Albumin, Puschino.

(*b*) BIOLOGICAL NITROGEN FIXATION IN SOIL BY (a) SYMBIOTIC AND (b) NON-SYMBIOTIC PROCESSES

**Participating Institutions**

*Indian side* :
1. Bose Institute, Calcutta.
2. Indian Agricultural Research Institute, New Delhi.
3. Tamil Nadu Agricultural University, Coimbatore.

*Soviet side* :
1. Institute of Microbiology, Moscow.

(c) MICROBIOLOGICAL TRANSFORMATION AND BIOCHEMICAL ENGINEERING

**Participating Institutions**

*Indian side* :
1. Tamil Nadu Agricultural University, Coimbatore.
2. Indian Agricultural Research Institute, New Delhi.
3. Central Drug Research Institute, Lucknow.

*Soviet side* :
1. Institute of Microbiology, Moscow.
2. Institute of Biochemistry and Physiology of Microorganisms, Puschino.

(d) GENETICS AND BREEDING OF CULTIVATED PLANTS

**Participating Institutions**

*Indian side* :
1. Indian Agricultural Research Institute, New Delhi.
2. G. B. Pant University of Agriculture and Technology, Pant Nagar.
3. National Botanical Research Institute, Lucknow.
4. Central Institute of Medicinal and Aromatic Plants, Lucknow.

*Soviet side* :
1. Institute of Cytology and Genetics, Novosibirsk.
2. Institute of General Genetics, Moscow.
3. Institute of Genetics and Cytology, Minsk.
4. Institute of Chemical Physics, Moscow.
5. Institute of Experimental Biology of Plants, Uzbekistan.
6. Institute of Genetics and Selection, Baku.
7. Main Botanical Garden, Moscow.

(e) MOLECULAR GENETICS AND GENE ACTION

**Participating Institutions**

*Indian side* :
1. Tata Institute of Fundamental Research, Bombay.
2. Indian Institute of Science, Bangalore.
3. Bose Institute, Calcutta.
4. Jawaharlal Nehru University, New Delhi.
5. Centre for Cellular and Molecular Biology, Regional Research Laboratory, Hyderabad.

*Soviet side* :
1. Institute of Molecular Genetics, Moscow.
2. Institute of Molecular Biology, Moscow.
3. Institute of Cytology and Genetics, Novosibirsk.

15. STUDIES ON TAXONOMY

**Participating Institutions**

*Indian side* :
1. Birbal Sahni Institute of Palaeobotany, Lucknow.

*Soviet side* :
1. Komorov Botanical Institute, Leningrad.

16. STUDY OF INORGANIC MATERIALS BY MAGNETIC RESONANCE SPECTROSCOPY

**Participating Institutions**

*Indian side* :
1. Indian Institute of Technology, Kanpur.
2. Tata Institute of Fundamental Research, Bombay.
3. Indian Institute of Science, Bangalore.
4. Indian Association for the Cultivation of Science, Calcutta.

*Soviet side* :
1. Institute of Chemistry, Tajikistan SSR, Dushanbe.
2. Institute of General and Inorganic Chemistry, Moscow.
3. Institute of Geochemistry and Physics of Minerals, Ukraine, SSR, Kiev.
4. Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow.

17. SCIENTIFIC AND TECHNICAL INFORMATION

**Participating Institutions**

*Indian side* :
1. Indian National Scientific Documentation Centre, New Delhi.

*Soviet side* :
1. All Union Institute of Scientific and Technical Information, Moscow.

18. HISTORY OF SCIENCE

**Participating Institutions**

*Indian side* :
1. Indian National Science Academy, New Delhi.

*Soviet side* :
1. Institute of History of Natural Sciences and Technology, Academy of Sciences, Moscow.
2. Uzbek Academy of Sciences.
3. Tajik Academy of Sciences.

19. RADIO SCIENCE

**Participating Institutions**

*Indian side* :
1. National Physical Laboratory, New Delhi
2. Physical Research Laboratory, Ahmedabad.
3. Vikram Sarabhai Space Centre, Thumba.
4. Andhra University, Waltair.
5. Institute of Radio Physics and Electronics, Calcutta.

*Soviet side* :
1. Izmiran, Moscow.
2. Sibizmir, Irkutsk.

20. GEOMAGNETIC AND GEOELECTRIC MICROPULSATIONS*

**Currently Participating Institutions**

*Indian side* :
1. National Geophysical Research Institute, Hyderabad.

*Soviet side* :
1. Institute of Physics of the Earth, Moscow.

21. DEEP SEISMIC SOUNDING STUDIES*

**Currently Participating Institutions**

*Indian side* :
1. National Geophysical Research Institute, Hyderabad.

*Soviet side* :
1. Geophysical Institute of the Ukranian Academy of Sciences, Kiev.
2. Institute of the Physics of Earth, Moscow.
3. Institute of Oceanology, Moscow.

The above programme might be periodically reviewed in order to add, modify or exclude certain subjects or institutions participating in the cooperation.

Cooperation on the subjects agreed upon will be carried out through joint research, exchange of scientists, holding of bilateral symposia, exchange of the results of the investigations etc.

The annual quota of exchanges on the subjects agreed upon, including visits for participation in bilateral symposia, will be equal to 50 man-months from each side. This quota can be increased by mutual consent.

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*In view of the fact that the first stage of cooperation in this field has been successfully completed, the further joint efforts of applied nature will be submitted for inclusion in intergovernmental programme of cooperation in applied sciences and technology. The two Academies, however, will continue exchanges of scientists and information for solving problems of fundamental nature.

Besides this an additional quota of 5 man-months is provided for exchange of scientists on subjects, which are not included in this programme. For example, it may be used for visits, aiming at finding out possibilities for future cooperation.

The duration of visits will, as a rule, range from two weeks to three months depending upon the nature of the scientific programme.

Done in Moscow on June 3, 1980 in two copies, each in Russian and English both being authentic.

Sd/-
A. P. ALEKSANDROV
President,
USSR Academy of Sciences.

Sd/-
V. RAMALINGASWAMI
President,
Indian National Science Academy.

*Annexure—VI*

# PROTOCOL

## On Discussions between the Delegations of the USSR Academy of Sciences and the Indian National Science Academy on the Present State and Further Development of Scientific Cooperation

From May 26 till June 3, 1980, a delegation of the Indian National Science Academy headed by Professor V. Ramalingaswami, President, visited the USSR at the invitation of the USSR Academy of Sciences.

During their stay in the USSR, the members of the Indian delegation visited research centres in Moscow, Leningrad, Novosibirsk and Puschino, where they had numerous meetings and discussions with the Soviet scientists and got acquainted with the research activities.

In the course of the visit, the Indian delegation had meetings and discussions in the Presidium of the USSR Academy of Sciences and was received by the Chairman of the State Committee on Science & Technology, Academician G. I. Marchuk.

The delegation of the USSR Academy of Sciences headed by Vice-President Academician Yu. A. Ovchinnikov and the delegation of the Indian National Science Academy headed by Dr V. Ramalingaswami (lists of the members of the delegations are appended as I and II) had friendly and sincere discussions on the present status and prospects of scientific cooperation for the next five years. The two sides have expressed deep satisfaction with the results achieved in a number of fields, envisaged by the programme of scientific exchanges and scientific cooperation such as geophysics, chemistry of natural products, low temperature physics, plasma astrophysics, studies on Lunar soil etc.

It was noted that the first stage of joint work on subjects "geomagnetic and geoelectric micropulsations" and "deep seismic sounding" had been completed. The two sides agreed to maintain in future, exchange of scientists and information on fundamental aspects of research, in these fields. At the suggestion of the Indian side, it was agreed that further joint efforts of an applied nature would be submitted for inclusion in the intergovernmental programme of cooperation in applied science and technology.

In the course of negotiations, the programme of scientific exchanges and cooperation between the two academies for the period 1980 to 1985 was agreed upon and signed. At the same time, a suggestion has been made to consider the possibility of incorporation into the programme of such problems proposed by the Indian side such as neurobiology, immunobiology and environmental physiology, homogenous and heterogenous catalysis, use of computer science for national development, mathematical modelling of meteorological processes including human effects. The sides will exchange concrete suggestions to this effect.

The organisational aspects for the realisation of the programme have been considered. The sides agreed that it would be reasonable to appoint coordinators for the elaboration and fulfilment of the programmes of cooperation. The financial terms of exchange of scientists (Appendix III) have also been agreed upon.

Both sides agreed to have periodical meetings at a working level, alternately in USSR and India, between the representatives of the Academy of Sciences, USSR and the representatives of the Indian National Science Academy in order to discuss questions relating to the progress of implementation and other issues that could arise in the course of cooperation.

Both sides demonstrated their strong desire to promote effective fulfilment of the agreed programme of cooperation.

The Indian delegation wishes to record its deep sense of appreciation and gratitude to the USSR Academy of Sciences for the organisation of an interesting and extensive programme of visits and for the warmth, hospitality and consideration shown to it during its visit to the Soviet Union.

Done in Moscow on June 3, 1980 in two copies, each in Russian and English languages, both copies being authentic.

Sd/-
A. P. ALEKSANDROV
President,
USSR Academy of Sciences.

Sd/-
V. RAMALINGASWAMI
President,
Indian National Science Academy.

# Delegation of the USSR Academy of Sciences

1. Academician Yu. A. Ovchinnikov,
   Vice-President,
   USSR Academy of Sciences.
2. Academician G. K. Skryabin,
   Chief Science Secretary,
   Presidium of the USSR
   Academy of Sciences.
3. Academician A. V. Fokin,
   Deputy Chief Science Secretary,
   Presidium of the USSR
   Academy of Sciences.
4. Professor V. L. Barsukov,
   Director,
   Vernadsky Institute of Geochemistry and Analytical Chemistry,
   Moscow.
5. Professor V. F. Bystrov,
   Deputy Director,
   Shemyakin Institute of Bio-organic Chemistry,
   Moscow.
6. Professor V. V. Migulin
   Director,
   Institute of Earth Magnetism, Ionosphere and Wave Propagation,
   Moscow.
7. Dr V. Cl. Starostenko,
   Deputy Director,
   Institute of Geophysics, Kiev.
8. Dr M. G. Hublaryan,
   Deputy Director,
   Institute of Water Problems,
   Moscow.
9. Professor M. B. Gohberg,
   Deputy Director,
   Institute of the Physics of the Earth,
   Moscow.
10. Mr N. I. Belyaev,
    Acting Head,
    Foreign Relations Department, USSR Academy of Sciences.
11. Mr N. M. Kiselev,
    Head of Division,
    Foreign Relations Department, USSR Academy of Sciences.
12. Mr Yu. P. Vlasov,
    Counsellor,
    USSR Embassy in India.

# Delegation of the Indian National Science Academy

1. Professor V. Ramalingaswami
   President,
   Indian National Science Academy,
   Director-General Indian Council of Medical Research,
   New Delhi.
2. Professor R. P. Bambah
   Vice-President,
   Indian National Science Academy,
   Professor of Mathematics, Panjab University, Chandigarh.
3. Dr A. P. Mitra
   Secretary,
   Indian National Science Academy,
   Head, Radio Science Division, National Physical Laboratory,
   New Delhi.
4. Dr B. S. Joshi
   CIBA-GEIGY Research Centre,
   Bombay.
5. Dr B. Lal
   Director,
   Physical Research Laboratory,
   Ahmedabad.
6. Professor O. Siddiqi
   Professor of Molecular Biology,
   Tata Institute of Fundamental Research,
   Bombay.
7. Mr S. Rajan
   Assistant Executive Secretary,
   Indian National Science Academy,
   New Delhi.
8. Dr Y. N. Bapat
   Counsellor,
   Embassy of India, Moscow.

*Appendix—III to Annexure VI*

## Financial Terms for Exchange Visits of Scientists between the Indian National Science Academy and the USSR Academy of Sciences

1. The sending side shall bear the expenditure for the international travel of its scientists and specialists from the place of their work to Delhi or to Moscow and back.
2. The receiving side shall provide the following facilities at its expense :
   (i) reception and send-off at airports including transfers to hotels and airports;
   (ii) tours of the scientists and specialists inside the country required for the fulfilment of the identified programme;
   (iii) furnished residential premises or hotel accommodation with necessary service facilities including airconditioning where necessary;
   (iv) medical facilities in case of sickness, including hospitalisation, medicines and emergency dental treatment;
   (v) visits to places of historical and cultural interests, depending on the time available; and
   (vi) payment of the airport tax at the time of departure of the delegation.
3. The receiving side shall provide a daily allowance of 11 Roubles per head in USSR and Rs. 100 in India towards board & out of pocket expenses.
4. The receiving side shall provide Interpreters, where necessary. The sending side may include in the delegation an interpreter to whom also the terms specified above shall apply.

*Annexure—VII*

## Publication Grants to Registered Societies, Associations and Institutions

| | *Name of the Society/Association/Institution* | *Quantum of Grant Recommended* |
|---|---|---|
| 1. | Bombay Natural History Society, Bombay | 5,000.00 |
| 2. | Institution of Chemists, Calcutta | 1,000.00 |
| 3. | Calcutta Mathematical Society, Calcutta | 1,000.00 |
| 4. | Indian Science News Association, Calcutta | 3,000.00 |
| 5. | International Society of Plant Morphologists, New Delhi | 2,000,00 |
| 6. | The National Academy of Sciences, Allahabad | 3,000.00 |
| 7. | Indian Society of Earth Sciences, Calcutta | 3,000.00 |
| 8. | Indian Chemical Society, Calcutta | 3,000.00 |
| 9. | The Indian Physical Society, Calcutta | 3,000.00 |
| 10. | The Asiatic Society, Calcutta. | 5,000.00 |
| 11. | Indian Science Congress Association, Calcutta. | 3,000.00 |
| 12. | The Current Science Association, Bangalore | 5,000.00 |
| 13. | Indian Society of Genetics and Plant Breeding, IARI, New Delhi | 3,500.00 |
| 14. | Acoustical Society of India, New Delhi | 3,000.00 |
| 15. | The Entomological Society of India, IARI, New Delhi | 2,000.00 |
| | Total | 45,500.00 |

*Annexure—VIII*

## Financial Support for Workshops, Winter Schools/Summer Schools and International Conferences

| | *Title of the Symposia, Seminars, etc., and Name of its Convener* | *Financial Support Recommended* Rs. |
|---|---|---|
| 1. | International Wetlands Conference (Dr Brij Gopal) | 5,000.00 |
| 2. | First Asian Congress of Fluid Mechanics (Professor S. Dhawan) | 5,000.00 |
| 3. | Symposium on Global Plate Tectonics and India (Professor B. B. S. Singhal) | 10,000.00 |
| 4. | International Symposium on Fifty Years of Botany-Progress and Prospects (Professor A. Mahadevan) | 10,000.00 |
| 5. | Symposium on Physics of Disordered Solids (Dr P. Shukla) | 5,000.00 |
| 6. | Seminar on Physics of Ion-Implanted Solids and its Applications (Professor Narendra Nath) | 5,000.00 |
| 7. | Symposium on Ecology of Insect Communities with Special Reference to Forest and Agro-ecosystems (Dr S. K. Sangal) | 3,000.00 |
| 8. | Symposium on Electronic Instrumentation and Control (Dr Harsh Vardhan) | 5,000.00 |
| 9. | International Symposium on Non-Linear Continuum Mechanics at the time of Silver Jubilee Congress of Indian Society of Theoretical and Applied Mechanics (ISTAM) (Professor S. Lal) | 5,000.00 |
| 10. | International Symposium on Bustards (Dr Harsh Vardhan) | 15,000.00 |
| 11. | Winter School on Some Recent Developments of Magnetism and Phase Transitions (Professor K. P. Sinha) | The Committee desired that Professor K. P. Sinha may be requested to send the complete details of the Winter School on the proforma and on receipt of the same it may be put up to the Officers' meeting. |
| 12. | Seminar on Exploration Geophysics in India with special reference to hard rock terrain (Professor V. L. S. Bhimasankaram) | 5,000.00 |
| | Total : | 73,000.00 |

# Minutes of the Ordinary General Meeting of the Indian National Science Academy held at 4 p.m. on Thursday 7 August 1980 at the Library Hall, Administrative Building, Udaipur University, Udaipur

**Members Present**

Dr V. Ramalingaswami, *President*
Professor R. P. Bambah, *Vice-President*
Professor B. Ramachandra Rao, *Treasurer*
Dr A. R. Verma, *Foreign Secretary*
Professor H. Y. Mohan Ram, *Editor of Publications*
Professor S. K. Trehan, *Editor of Publications*
Dr M. G. Deo, *Secretary*
Dr A. P. Mitra, *Secretary*
Dr F. Ahmad
Professor T. R. Anantharaman
Dr D. P. Antia
Professor P. K. Bhattacharyya
Dr S. C. Bhattacharyya
Dr R. R. Daniel
Dr D. S. Kothari
Dr C. R. Krishnamurti
Dr B. C. Kundu
Professor G. K. Manna
Professor R. C. Mehrotra
Professor R. C. Misra
Professor N. Balakrishnan Nair
Dr H. L. Nigam
Dr A. S. Paintal
Dr Yash Pal
Dr Supriya Roy
Professor A. K. Sharma
Professor (Mrs.) Archana Sharma
Professor M. M. Sharma
Dr R. Ramanna

The President expressed pleasure at the presence of Dr D. S. Kothari, Past-President of the Academy. He also expressed grateful thanks to the Vice-Chancellor of the Udaipur University for the excellent arrangements made for holding the meeting.

**Condolence on the passing away of Dr J. N. Bhar, a Distinguished Fellow of the Academy**

Reference was made to the death of Dr J. N. Bhar a distinguished Fellow of the Academy, all present standing in silence for two minutes as a mark of respect to the deceased.

**Confirmation of the Minutes of the Ordinary General Meeting held on 8th May 1980**

The minutes of the Ordinary General Meeting held on the 8th May 1980 read by Dr A. P. Mitra, Secretary, was confirmed.

**Admission of Fellows under Rule 13**

No Fellow was present for admission under Rule 13.

**Scrutiny of Voting Papers for Amendments of Rules 5, 6, 19, 36(iii), 37(a), 37(b), 38, 42, 51, 53(a), 54, 56(c)(iv), 56(c)(v), 58(a), 58(b), 59(c), 59(g), 68, 70 and 74**

The President appointed Professor S. K. Trehan as scrutineer and requested him to call on any other Fellow present to assist him. Professor Trehan took the assistance of Professor H. Y. Mohan Ram. Scrutiny of voting papers for amendment of rules resulted in the following :—

| | *For* | *Against* |
|---|---|---|
| Amendment of Rule 5 | 138 | 3 |
| Amendment of Rule 6 | 137 | 2 |
| Amendment of Rule 19 | 135 | 5 |
| Rule 36(iii) | 135 | 2 |
| Rule 37(a) | 134 | 1 |
| Rule 37(b) | 134 | 5 |
| Rule 38 | 136 | 4 |
| Rule 42 | 140 | 0 |
| Rule 51 | 140 | 1 |
| Rule 53(a) | 137 | 8 |
| Rule 54 | 129 | 9 |
| Rule 56(c)(iv) | 133 | 3 |
| Rule 56(c)(v) | 132 | 4 |
| Rule 58(a) | 123 | 15 |
| Rule 58(b) | 132 | 4 |
| Rule 59(c) | 137 | 2 |
| Rule 59(g) | 126 | 9 |
| Rule 60 | 139 | 2 |
| Rule 70 | 140 | 1 |
| Rule 74 | 129 | 12 |

As more than three fourths of the votes polled were in favour of the proposals, the President declared as carried the proposed amendments as those rules (as given in the *Appendix–I*).

**Announcement of Awards of Science Academy Medals for Young Scientists for 1980**

The President announced the awards of Science Academy Medals for Young Scientists, 1980. The list of awardees is given in *Appendix–II.*

At the general discussion that followed there was brief discussion on INSA contributions to the popularisation of science. INSA has ability and willingness to assist NCERT for publications for high school students e.g., children's books as well as self-evaluation manuals. Lectures have been arranged this year as in the past for school audiences. The fellows emphasised the need of audiovisual aids as well as lectures in Indian languages as has been realized also from the efforts of the Kerala Sahitya Sangam in their Science Workshops. The Popularisation of Science Committee may look into the matter of preparation by some suitable agency of audiovisual aids of high quality.

While awaiting the counting of votes, the meeting took up the discussion on the DST enquiry for possible programmes to enthuse young people for science. Professor D. S. Kothari also participated. The President referred to the society of DAYS in England. The possible methods of creating enthusiasm as discussed previously by the officers are :—

(a) Lectures, Films, travelling exhibitions.

(b) U.G.C. type career awards open also to scientists who are not in any professional employment.

(c) Post-Doctorate Fellowships.

Professor R. C. Mehrotra commented that in the past brilliant students flocked to science but now there is fall in enrolment in pure science. He felt that a suitable assured career for post-doctorate scholars is necessary. Dr D. P. Antia compared the emoluments of scientists at young age with other professionals.

The discussion then shifted to research and assistance to talented scientists. Professor D. S. Kothari remarked that the very best will need no motivation, but only good library and experimental facilities within reach. However, for the remaining talented and young men, subject-wise effort should be made in identifying them, demonstration of support by scholarships, medals, visits to centres of research etc. It was agreed that the INSA may set up a standing panel for watching this effort regarding identification and encouragement to individuals and to recommend suitable books every five years to school and college libraries in various subjects so that students and teachers can derive some inspiration.

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The above Minutes were later confirmed and signed.

*Appendix–I to Minutes*

| *Existing Rule* | *Amended Rule* |
|---|---|
| **Rule 5** | |
| The Administration, direction and management of the affairs of the Academy shall be entrusted to a Council composed of the Officers of the Academy namely, a President, two Vice-Presidents, a Treasurer, two Secretaries, a Foreign Secretary and two Editors of Publications together with 18 other Fellows making a total of 27. In addition, there shall be provision for an additional Member of the Council to be nominated by each of the Cooperating Academies and the Indian Science Congress Association from amongst the Fellows of the Academy. Further, there shall be provision for the Government of India to nominate from amongst the Fellows of the Academy their representative on the Council as an Additional Member. Further the immediate Past-President shall be an ex-officio Additional Member of the Council. | The administration, direction and management of the affairs of the Academy shall be entrusted to a Council composed of the Officers of the Academy namely, a President, two Vice-Presidents, a Treasurer, two Secretaries, a Foreign Secretary and two Editors of Publications together with 18 other Fellows making a total of 27. In addition, there shall be a provision for an additional Member of Council to be nominated by each of the cooperating Academies i.e., the Asiatic Society, Calcutta; the Indian Academy of Sciences, Bangalore and the National Academy of Sciences (India), Allahabad and the Indian Science Congress Association from amongst the Fellows of the Academy. Further, there shall be provision for the Government of India to nominate from amongst the Fellows of the Academy their representative on the Council as an Additional Member. Further, the immediate Past-President shall be an ex-officio additional Member of the council. |
| **Rule 6** | |
| Not more than one of the Offices of the President, Vice-President and Secretary shall be held by the same person. | No Council member can hold more than one Office at a time except in circumstances relating to interim vacancies stated in Rule 39. |
| **Rule 19** | |
| The Subscription of Fellows shall be Rs. 36.00 per year. Fellows who became non-resident before 1950 will continue to pay Rs. 16/- per annum according to old rules. In the case of a Fellow, who is a member of other Science Academy or Academies in India working in cooperation with the INSA in accordance with the regulation for co-operating Academies, a reduction of Rs. 12/- annually, shall be allowed on the full subscription of Rs. 36/- on the evidence of a certificate from a co-operating Academy, provided that in subsequent years, he himself certifies that he continues to be member of a co-operating Academy. In the case of a fellow elected under the provisions of Rules 7(e), the Council may, at their discretion, not require payment of the annual subscription.<br>Such Fellows as have already paid their subscription for 30 years will be exempted from further payment of subscription. | The Subscription of Fellows shall be Rs. 36/- per year. Fellows who became non-resident before 1950 will continue to pay Rs. 16/- per annum according to old rules. In the case of a Fellow, who is a member of some other Science Academy or Academies in India working in cooperation with the INSA in accordance with the regulation for co-operating Academies, a reduction of Rs. 12/- annually, shall be allowed on the full subscription of Rs. 36/- on the evidence of a certificate from a co-operating Academy, provided that in subsequent years, he himself certifies that he continues to be a member of a co-operating Academy.<br>Such Fellows as have already paid their subscription for 30 years will be exempted from further payment of subscription.<br>Fellows above the age of 65 may be exempted from the payment of the annual INSA subscription. |

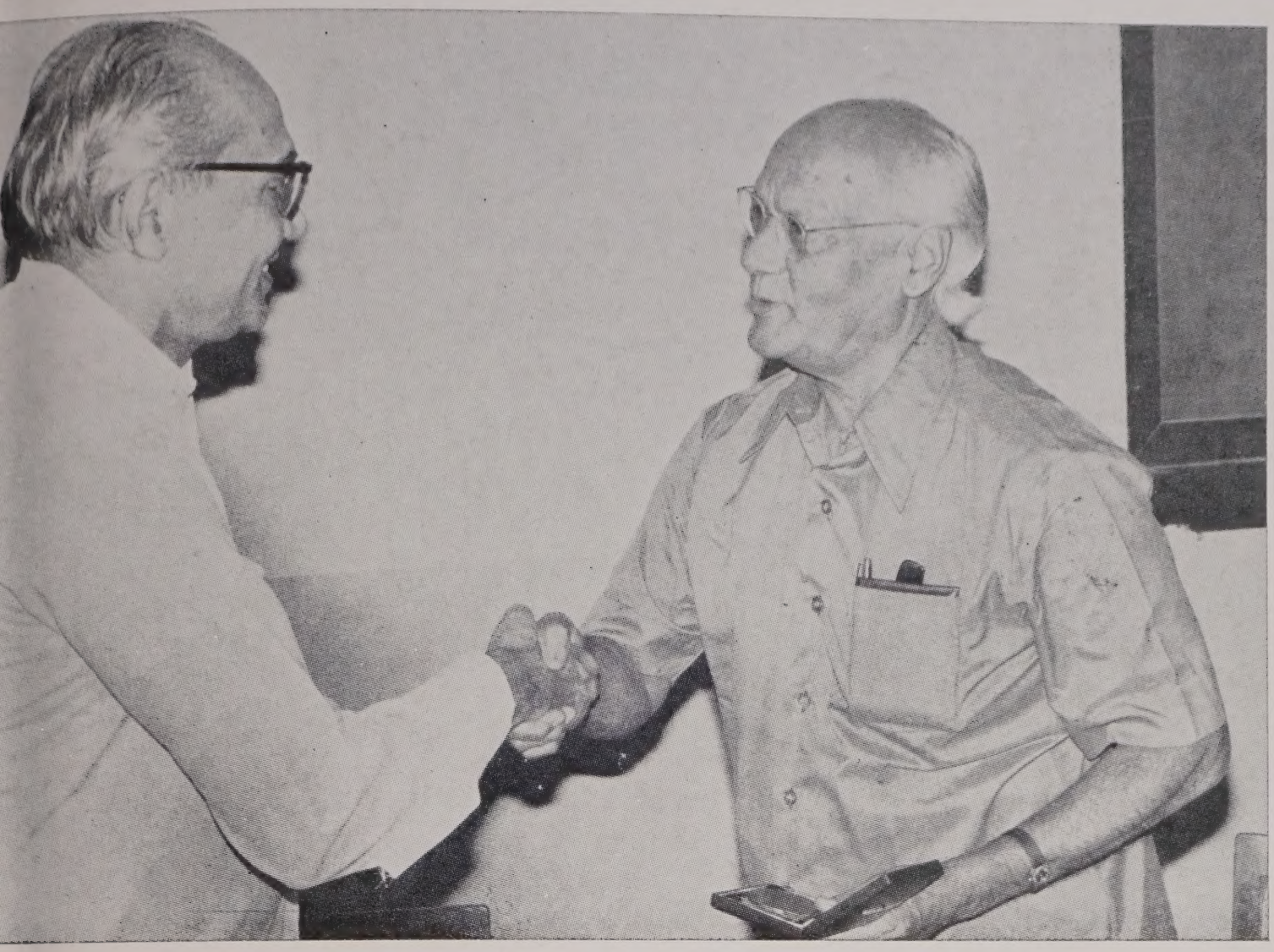
| *Existing Rule* | *Amended Rule* |
|---|---|
| **Rule 36(iii)** | |
| The suggestions received shall be circulated to the members of the Council by a date prescribed by the Council for expression of their views, and considered at the meeting of the Council to be held in August when final nomination shall be made out of the names suggested. | The suggestions received shall be circulated to the Members of the Council by a date prescribed by the Council for expression of their views, and considered at the Meeting of the Council to be held in August when final nominations shall be made out of the names suggested. While nominations are discussed, members of the Council being considered for a position as an Office Bearer of the Council shall not participate in the selection procedures for the respective position. |
| **Rule 37(a) & (b)** | |
| (*a*) No person shall hold the Office of the President for more than two consecutive years, nor after vacating office shall a person who has held the Office of the President be eligible for re-election until, after the 5th Anniversary General Meeting following that at which he vacated the Office of President. No Vice-President shall be eligible to hold Office as such for more than two consecutive years, and no person on retirement from the office of the Vice-President shall be eligible for re-election to the same Office until after the expiry of one year. | (*a*) No person shall hold the Office of the President for more than two consecutive years, nor after vacating office shall a person who has held the office of President be eligible for re-election until after the fifth Anniversary General Meeting following that at which he vacated the Office of Presi dent. No Vice-President shall be eligible to hold Office as such for more than two consecutive years, and no person on retirement from the office of the Vice-President shall be eligible for re-election to any Office until after the expiry of two years except the Office of the President. |
| (*b*) The Secretaries, the Foreign Secretary, the Treasurer and the Editors of Publications shall be eligible to hold office for a period of four consecutive years and shall not be eligible for re-election to the same Office until after the expiry of two years. | (*b*) The Secretaries, the Foreign Secretary, the Treasurer and the Editors of Publications shall be eligible to hold office for a period of four consecutive years and shall not be eligible for re-election to any office until after the expiry of two years except the Office of the President. |
| **Rule 38** | |
| Each year, six members of the Council not being the President, Vice-President, Treasurer, Editors of Publications or Secretaries shall retire from the Council and shall not be eligible for re-election until after the lapse of one year from the date of their retirement. The retirement shall be decided by seniority, except in so far as vacancies have not otherwise occurred In the event of equal seniority, the seniority, shall be decided by lot. Interim vacancies shall be filled by the Council only for the unexpired period. | Each year, six members of the Council not being the President, Vice-Presidents, Treasurer, Editors of Publications or Secretaries shall retire from the Council and shall not be eligible for re-election to the membership of the Council until after the lapse of three years from the date of their retirement. The retirement shall be decided by seniority, except in so far as vacancies have not otherwise occurred. In the event of equal seniority, the seniority shall be decided by lot. Interim vacancies shall be filled by the Council only for the unexpired period. |
| **Rule 42** | |
| In the absence from headquarters of either of the Secretaries or the Treasuer, the President shall designate one of the Members of the Council to continue his functions until his return to headquarters, subject to the confirmation of the Council at the first opportunity. Such Member of the Council shall be entitled to sign papers for the Secretary or the Treasurer respectively. | In the absence from the Headquarters of both the Secretaries or the Treasurer, the President shall designate one of the Members of the Council to continue his functions until his return to headquarters, subject to the confirmation of the Council at the first opportunity. Such members of the Council shall be entitled to sign papers for the Secretary or the Treasurer respectively. |

| *Existing Rule* | *Amended Rule* |
|---|---|
| **Rule 51** | |
| The Editor or Editors shall be responsible for the preparation and printing of the publications of the Academy and shall have the right of direct correspondence with the authors and with the press. He or they must be chosen from amongst Members of the Council. | The Editor or Editors shall be responsible for the preparation and printing of the publications of the Academy and shall have the right of direct correspondence with the authors and with the press. |
| **Rule 53(a)** | |
| Seven Fellows shall constitute a quorum. | Ten Fellows shall constitute a quorum. |
| **Rule 54** | |
| The General Meeting shall be held at such times and in such places as the Council may decide, so that the total number of General Meetings held during a calendar year is not less than five, of which one should be held at the city selected for the Meetings of the Indian Science Congress Association for that year and during or close to the session thereof; this Meeting shall be called the Anniversary General Meeting. One of the Meetings held during the year shall be termed the Annual General Meeting, and others, the Ordinary General Meetings. | The General Meeting shall be held at such times and in such places as the Council may decide, so that the total number of General Meetings held during a calendar year is not less than four, of which one should be held at the city selected for the meetings of the Indian Science Congress Association for that year and during or close to the session; this meeting shall be called the Anniversary General Meeting. One of the Meetings held during the year shall be termed the Annual General Meeting, and others, the Ordinary General Meetings. |
| **Rule 56 (c-iv & v)** | |
| (*iv*) Elect the Officers and other Members of the Council for the ensuing year as provided in Rule 36. | (*iv*) Announce the Officers and other Members of the Council for the ensuing year as provided in Rule 36. |
| (*v*) Elect Fellows unless the Council decide that this can be more conveniently done at a meeting of the Council or at an Ordinary General Meeting. | (*v*) Announce Fellows unless the Council decides that this can be more conveniently done at a Meeting of the Council or at an Ordinary General Meeting. |
| **Rule 58 (a) & (b)** | |
| (*a*) Such Meetings may be convened by a majority of the Council and shall be convened by the President, when called on to do so by a requisition signed by not less than ten Fellows, and stating the special business for which it is desirable that an Extraordinary General Meeting should be convened. | (*a*) Such Meetings may be convened by a majority of the Council, and shall be convened by the President, when called on to do so by a requisition signed by not less than forty Fellows and stating the special business for which it is desirable that an Extraordinary General Meeting should be convened. |
| (*b*) Notice of the day and hour of the Meeting, and of the special business to be transacted thereat, shall be given to Fellows not less than one month before the date of the Meeting provided that, if the business be very urgent, it should be competent to the Council to substitute any earlier notice than that of one month; but no business of the nature specified in Rule 63, Clause (c) shall be deemed urgent within the meaning of this clause. | Notice of the day and hour of the Meeting, and of the Special business to be transacted thereat, shall be given to Fellows within one month of receiving the request for the Extraordinary Meeting and before one month of the date of the Meeting, provided that, if the business be very urgent, it should be competent to the Council to substitute any earlier notice than that of one month; but no business of the nature specified in Rule 63, Clause (c) shall be deemed urgent within the meaning of this clause. |

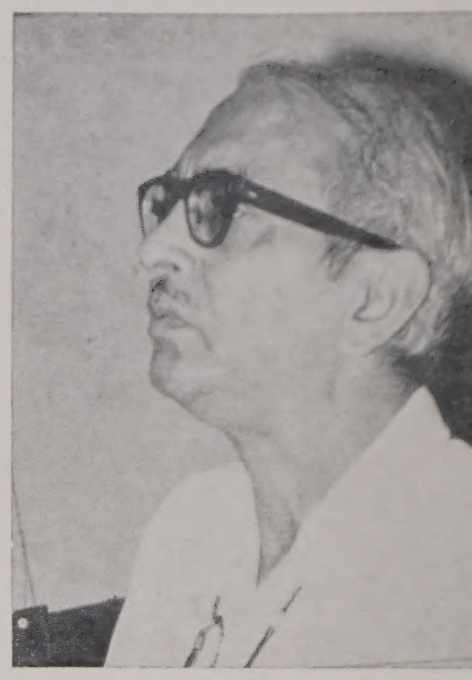
| *Existing Rule* | *Amended Rule* |
|---|---|
| **Rule 59 (c) & (g)** | |
| (*c*) Five Members shall form a quorum. | (c) Ten Members shall form a quorum, for the Statutory Meeting of the Council. No quorum is needed for the Non-Statutory meeting of the Council. |
| (*g*) The voting on any question except when it be one of adjournment shall on the demand of any Fellow present, be postponed to the next ensuing Meeting, when such question shall be disposed of. | (g) The voting on any question except when it be one of adjournment shall, on the demand of any Fellow present, be postponed to the next ensuing meeting provided it has the concurrence of the majority of the Council present. |
| **Rule 60** | |
| The Council may elect, from among their own body, Committees for the consideration of special subjects. They may also appoint Foreign Fellows (or Fellows other than Members of the Council) who are competent and well versed in the subjects to be referred to these Committees, to be Members of such Committees. | The Council may elect, from among the General Body of Fellows, Committees for the consideration of special subjects. They may also appoint Foreign Fellows who are competent and well versed in the subjects to be referred to these committees, to be Members of such Committees. |
| **Rule 70** | |
| No person appointed to any office in the Academy to which a salary or any emolument, other than a conveyance allowance, is attached shall have the privilege of voting. If any Fellow be appointed to any such office, he shall be incapable of voting at the Meeting of the Academy as long as he continues to hold it, but shall not be deprived of his other privileges of Fellowship. | No person appointed to any office in the Academy to which a salary or any emolument, other than a conveyance allowance, is attached shall have the privilege of voting. If any Fellow be appointed to any such office, he shall not be entitled to vote at the meeting of the Academy as long as he continues to hold it but shall not be deprived of his other privileges of Fellowship. |
| **Rule 74** | |
| When the introduction of any new Rule, or the alteration or repeal of any existing rule, is recommended by the Council, or proposed by ten or more Fellows, the Council shall cause to be sent to every Fellow of the Academy entitled to vote, a statement of the proposed changes and the reasons for them, with a view to the votes of the General Body of Fellows being taken as directed in Rule 65. Provided always that no change in the Rules shall be valid unless a majority of three-fourth of the Fellows who have voted shall be in favour of the proposed changes. | When the introduction of any new Rule, or the alteration or repeal of any existing rule, is recommended by the Council, or proposed by ten or more Fellows, the Council shall cause to be sent to every Fellow of the Academy entitled to vote, a statement of the proposed changes and the reasons for them, with a view to the votes of the General Body of Fellows being taken as directed in Rule 65, provided always that no change in the Rule shall be valid unless a majority of the two-third of the Fellows who have voted shall be in favour of the proposed changes. |

# Science Academy Medals for Young Scientists—Awardees, 1980

1. DR PRABHA AGRAWAL (*b.* 15-12-1951) Department of Life Sciences, University of Indore, Khandwa Road, Indore
   —For her outstanding work on ovarian histochemistry and enzyme interactions.
2. DR D. V. AMLA (*b.* 16-7-1950) Algae-Laboratory, National Botanical Research Institute, Lucknow-226 001
   —For his outstanding work in the field of repair and mutagenesis of cyanophage AS-1 infecting the alga, *Anacystis nidulans*.
3. SHRI R. BALASUBRAMANIAM (*b.* 15-3-1951) Department of Mathematics, Tata Institute of Fundamental Research, Bombay.
   —For his work in the field of Analytic Number Theory—Titchmarsh problem on the mean value of the Zeta function, contribution to the waring problem.
4. DR M. A. BARMA (*b.* 27-12-1950) Fellow (Physics), Tata Institute of Fundamental Research, Bombay.
   —For his original contribution in the critical point phenomena in magnetic polymers dilute magnetic systems.
5. SHRI D. K. CHAKRABARTI (*b.* 24-8-1948) Department of Pharmaceutics, Institute of Technology, Banaras Hindu University, Varanasi-221 005
   —For elucidating all aspects of Fusarial wilt infection and its control in safflower.
6. DR S. S. MEHETRA (*b.* 12-6-1952) All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapith, Rahuri, District Ahmednagar, Maharashtra
   —For developing techniques of producing hybrid cotton seed and male steriles in arboreum cotton.
7. SHRI MADHAV V. NORI (*b.* 14-12-1949) School of Mathematics, Tata Institute of Fundamental Research, Bombay
   —For his work on Algebraic Geometry—Construction of the fundamental group scheme, complete intersection property of fine curves.
8. DR D. PANDEY (*b.* 24-3-1952) School of Materials Science & Technology, Institute of Technology, Banaras Hindu University, Varanasi-221 005
   —For his outstanding work in the field of Materials Science & Technology, particularly of silicon carbide.
9. DR N. PATTABHIRAMAN (*b.* 24-11-1951) Research Associate, Indian Institute of Science, Bangalore-560 012
   —For his outstanding work on the conformation and structure of DNA and its derivatives.
10. DR SUDHIR PAUL (*b.* 29-10-1952) Junior Research Officer, All India Institute of Medical Sciences, Ansari Nagar, New Delhi-110 016
    —For his good work in the structure and function of Syncytiotrophoblast.
11. DR S. S. PILLAI (*b.* 9-6-1953) Kothari Centre for Gastroenterology, The Calcutta Medical Research Institute, Calcutta
    —For development and application of a novel matrix technique for protein-protein monoconjugation.
12. SHRI E. S. P. REDDY (*b.* 1-5-1950) Centre for Cellular & Molecular Biology, Regional Research Laboratory, Hyderabad-500 009
    —For his outstanding work in isolation and characterisation and studies on the mechanism of two new interesting proteins for bovine seminal plasma.
13. DR N. SATHYAMURTHY (*b.* 10-7-1951) Department of Chemistry, Indian Institute of Technology, Kanpur-208 016
    —For his work on molecular reaction dynamics.
14. DR A. K. SAXENA (*b.* 1-7-1950) Department of Electronics & Communication Engineering, University of Roorkee, Roorkee
    —For his outstanding contributions in solid-state electronics.
15. SHRI V. N. VASUDEV (*b.* 29-9-1948) Department of Mines & Geology, Race Course Road, Bangalore-560 001
    —For his outstanding contributions to the major trace and rare earth element geochemistry of the mineralized metavolcanic rocks of Kolar, Hutti and Chitradurg areas and for his work for tracing the tectonic environments of mineralization in these areas.

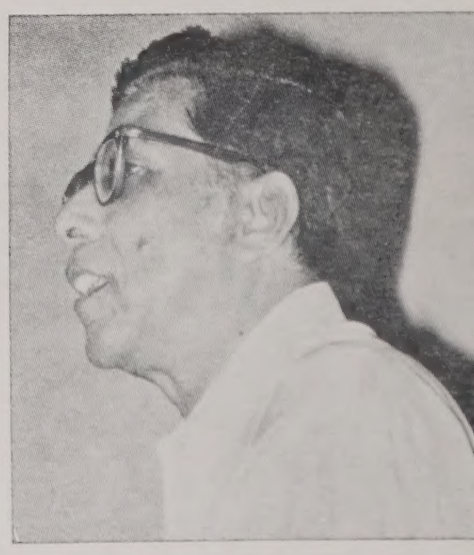


*Ramalingaswami, President, INSA congratulates Dr M.S. Randhawa, (Vice-President INSA) on ing the Silver Jubilee Commemoration Medal–1979 on 4 October 1980. Below : Dr B. P. Pal is being presented the Aryabhata Medal–1980 on 4 October 1980.*



*Dr Sukh Dev was awarded the Vishwakarma Medal-1979 and honorarium on 4 October 1980. Dr Sukh Dev delivered the Medal Lecture on the same day at the Academy.*

*Dr A. G. Datta, received the remuneration of the Bashamber Nath Chopra Lectureship–1980 on 4 October 1980. On the same day he delivered the lecture at the Academy.*



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